AERONAUTICAL ENGINEERING REVIEW

INSTITUTE OF THE AERONAUTICAL SCIENCES

MARCH 1948

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Typical ice formation on propeller blade before applying current to Goodyear Iceguard

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Iceguard—T. M. The Goodyear Tire & Rubber Company

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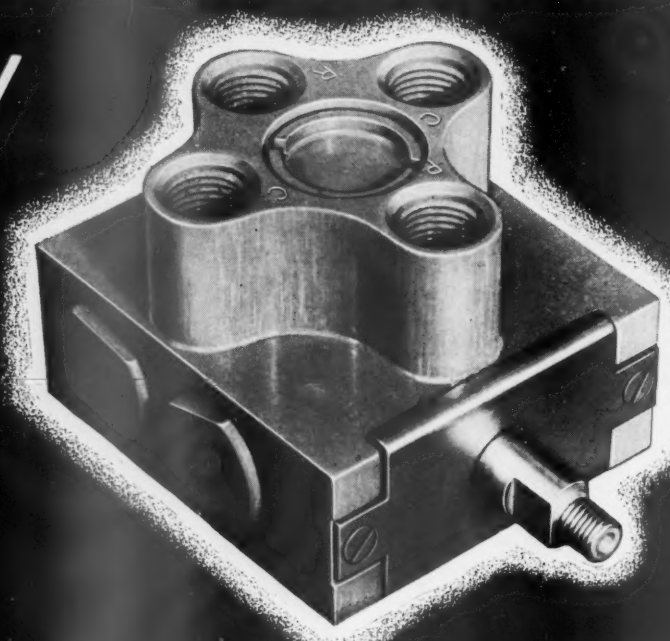
-the Electrol Open Center Selector Valve



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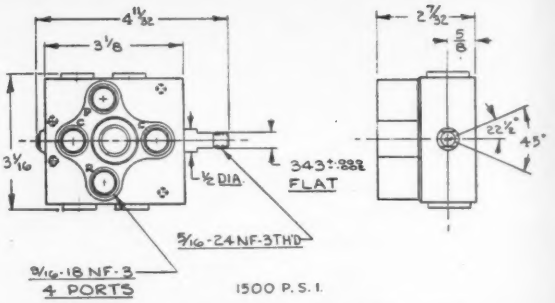

Diagrammatic sketch of Open Center Selector Valve.

Electrol

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Cover—Meteorological Session at the Sixteenth Annual Meeting.

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AERONAUTICAL ENGINEERING REVIEW

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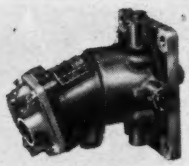
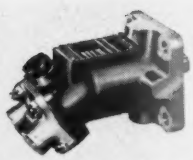
North American Aviation's B-45

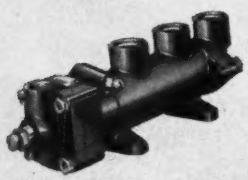
Uses VICKERS HYDRAULIC EQUIPMENT



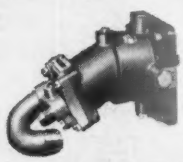
Vickers Model PF-3909 Series Constant Displacement Piston Type Pump



Vickers Model MF-3906 Series Constant Displacement Piston Type Motor



Vickers Power Brake Valve Model AA-13150 Series has true "hydraulic feel"



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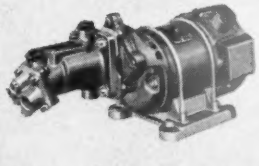
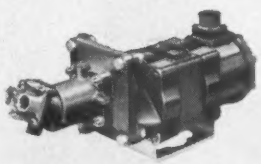


Vickers Model AA-19020 Motor-pump



Vickers Model AA-19024 Motor-pump

Vickers Model AA-14307-A 7½" Accumulator

Vickers Model AA-11300 Series Balanced Piston Relief Valve

Vickers Model AA-12300 Series Balanced Piston Relief Valve (Vent)

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I.A.S. News

A Record of People and Events of Interest to Institute Members

Annual Business Meeting of the Institute

Reports of President, Treasurer, and Director

THE SIXTEENTH ANNUAL MEETING of the members of the Institute was held at the Hotel Astor, New York, January 28, 1948. Preston R. Bassett, President of the Institute, presided.

Fred K. Teichmann, Teller, reported that he had received and counted 1,503 valid proxies for voting at the Annual Meeting—a quorum of the voting membership.

Elmer A. Sperry, Jr., Chairman of the Nominating Committee, placed in nomination the following members for election to vacancies on the Council: John K. Northrop, Smith J. De France, C. L. Johnson, R. P. Lansing, Earle D. Osborn, Preston R. Bassett, and Sherman M. Fairchild, for a term of 1 year each; Rex B. Beisel, William Bollay, Charles H. Colvin, Leroy R. Grumman, and L. B. Richardson, for a term of 3 years each; and the following area councilors for a term of 1 year each: Eastern Area—R. G. Robinson, A. J. Thieblot; Central Area—F. O. Carroll, Kenneth Razak; Western Area—Jack Mason, George Schairer. On motion duly made, seconded, and carried, they were unanimously elected. The following were nominated and elected in like manner to serve on the Nominating Committee for 1948: Charles H. Colvin, Chairman, Wellwood E. Beall, Frank W. Caldwell, Hugh L. Dryden, J. C. Hunsaker, Clark B. Millikan, A. E. Raymond, and T. P. Wright.

The Annual Reports of the President, Treasurer, and Director were read and approved. (See the following pages for the complete reports.)

The Secretary presented a list of honors conferred by the Institute in 1947 as follows:

The Sylvanus Albert Reed Award to Galen B. Schubauer, Chief, Aerodynamics Section, National Bureau of Standards, and Harold K. Skramstad, Chief, Guided Missiles Section, National Bureau of Standards; The Thurman H. Bane Award to Adolph L. Berger, Mechanical Engineer of Air Materiel Command, Wright Field; The Robert M. Losey Award to Col. Benjamin G. Holzman, U.S.A.F., Office of the Deputy Chief of Air Staff for Research and Development; The John Jeffries Award to J. Winfred Tice, M.D., Consultant in Aviation Medicine, R.C.A.F.; The Octane Chanute Award to Lawrence A. Clousing, Head of Flight Section, Ames Aeronautical Laboratory, N.A.C.A.; and The Lawrence Sperry Award to Comdr. Noel A. M. Gayler, Executive Director, Special Devices Center, Sands Point.

Honorary Fellowship in the Institute to: James H. Doolittle, Vice-President and Director, Shell Union Oil Corporation.

Fellowship in the Institute to: Ira H. Abbott, Assistant Chief of Research, Langley Memorial Aeronautical Laboratory, N.A.C.A.; C. F. Baker, Chief Engineer, Hamilton Standard Propellers Division, United Aircraft Corporation; Carlton Kemper, Executive Engineer, Flight Propulsion Research Laboratory, N.A.C.A.; A. M. Kuethe, Professor of Aerodynamics, University of Michigan; F. A. Louden, Head of Aerodynamics and Hydrodynamics Branch, Bureau of Aeronautics, Navy Department; W. G. Lundquist, Chief Engineer, Wright Aeronautical Corporation; J. S. McDonnell, President, McDonnell Aircraft Corporation; L. B. Richardson, Vice-President, Curtiss-Wright Corporation; W. R. Sears, Director, Cornell University Graduate School of Aeronautical Engineering; Robert M. Stanley, Vice-President of Engineering, Bell Aircraft Corporation.

Elmer A. Sperry, Jr., Chairman of the Nominating Committee

The Secretary announced that the Council had elected the following officers of the Institute for 1948: President, John K. Northrop; Vice-Presidents, Smith J. De France, C. L. Johnson, R. P. Lansing, and Earle D. Osborn; Director, S. Paul Johnston; Executive Vice-President, Bennett H. Horchler; Treasurer, Sherman M. Fairchild; Secretary, Robert R. Dexter; and Controller, Joseph J. Maitan.

ROBERT R. DEXTER, SECRETARY

I.A.S. Calendar

March 19	Flight Propulsion Meeting, Cleveland
July	Annual Summer Meeting, Los Angeles

For details see page 33.

President's Report for 1947

As I CLOSE MY TERM as President of the Institute, I am pleased to report that the year just completed has been one of satisfactory progress and one filled with events that have increased the value and prestige of the Institute.

To the aeronautical industry, which we represent, it has been a trying year. Reconversion and recovery in our fields of interest have had more time lag than in other fields, mainly because no one knew to what we were reconverting.

In this period of uncertainty the Institute management had two responsibilities: (1) The services to its members had to be kept up to a maximum as they were needed more than ever; and (2) the budget had to be watched carefully because of the uncertainty of income during this period. I am pleased to report that during the year both of these responsibilities have been successfully met. Services were not curtailed; the number of technical meetings remained high; the circulation of our publications was increased; the library services continued with improved efficiency; and we ended the year within our budget and without a deficit.

The first project of the year which broke new ground was Project A, the Standard Aeronautical Index. After considerable study on the part of the Army, the Navy, and others interested in the collating of aeronautical information, it was decided that the Institute should undertake the job of preparing a Standard Aeronautical Index, since it was both technically qualified and unbiased. Consequently, a contract was entered into with the Army Air Forces for the preparation of such an index. Although administered by Wright Field, the Navy, N.A.C.A., R.D.B., and the Special Libraries Association are cooperating. We were most fortunate in obtaining the services of Leslie E. Neville as Director of this project, and I am pleased to report that Mr. Neville and his staff have been making very satisfactory progress on this important assignment.

In August of last year we celebrated the Fifteenth Anniversary of the founding of the Institute at our annual summer meeting at Los Angeles. At the banquet on this occasion, The Thurman H. Bane Award was presented to Adolph L. Berger. By presenting some of the awards on the West Coast at the summer meeting, we feel that there is a more equitable division of the Institute's functions between the East and West Coast and also that it will relieve the rather heavy program of Honors Night.

The high point of your President's term in office was the first joint meeting of the Royal Aeronautical Society and the Institute, held in London, September 2 to September 14, 1947. At the cordial invitation of Sir Frederick Handley-Page, President of the Royal Aeronautical Society, thirty of us from the Institute made the trip to England. It would be impossible in this brief report to convey either the extent of the hospitality or the value of the meetings and contacts which we received during our stay with our British hosts. Excellent technical papers and discussions were presented by both British and American members. We visited many of the larger airplane and engine manufacturing plants, as well as the Government Aeronautical Laboratories at Farnsborough. We were guests of the Lord Mayor of London at Guildhall and of the government at Lancaster House. The cordial relations established will, I am sure, continue and grow through subsequent joint meetings. It is our hope that we will be able to arrange a return meeting with the Royal Aeronautical Society in this country in the near future.

Last August, the Institute was called upon to make a rather serious sacrifice in the broad interests of aviation. President Truman had just appointed an Air Policy Commission to investigate and report on the numerous problems facing both the Government and the aviation industry. The Commission needed an executive director—Paul Johnston was the man. It was with mixed feelings—of pride that they should turn to us and of concern as to the burden thrown on the remainder of the Institute staff—that the Council gave Johnston permission to undertake the assignment. Now the tremendous job has been accomplished with great success and on schedule. Our Director is again back, devoting full time to the Institute. The sacrifice was worth while. The Chairman of the Commission has given high praise to the value of Johnston's services, and it has brought prestige to the Institute.

I am glad to take this opportunity to commend the members of the staff of the Institute for the excellent way that they have carried out their responsibilities while Mr. Johnston has been absent in Washington. It is a fine commentary on our organization that things ran with the same smoothness and efficiency during this whole period.

P. R. BASSETT, *President*

Treasurer's Annual Report

I AM GLAD TO BE ABLE TO REPORT that in the fiscal year ended September 30, 1947, the Institute operated on a balanced budget. In view of the somewhat critical financial position of the aircraft industry and considering the continuance and expansion of the Institute's services, it is gratifying that we were able to break even during the year.

The support that has been given to the Institute by its members demonstrates the continued necessity for a central organization with facilities available for the dissemination of technical and scientific information required for the proper maintenance of research and development.

It has been the Council's firm opinion that the individual and Corporate members are entitled to receive the utmost from membership in the Institute, regardless of the status of current income. This feeling has pervaded the entire staff from the mail-boy to your Director. It is because of their coordinated efforts that we have been able to reach and maintain maximum operating efficiency with a minimum of expense and personnel.

The complete financial statement for the fiscal year ending September 30, 1947, is available for your inspection, and is published in abstract in this issue of the REVIEW. During the year, in spite of an overall reduction in expense of approximately 20 per cent over 1945–1946 operations, the budget for expenses of meetings was increased by 55 per cent and approximately 15 per cent more was spent in the production of the JOURNAL. This is a measure of increased service to the membership.

During the war years a small reserve fund was built up as a cushion to be used when and if necessary to maintain our high standards. These reserves were not needed to cover Institute operations during the past year and are still available to assist in any financial emergency to ensure continuous service to our membership.

The Council has established a budget for the current fiscal year which will enable us to provide, without curtailment in service to be rendered, all of the instruments indispensable to engineers for the stimulation of the mind in connection with the art and science of aeronautics.

The books of account of the Institute were examined by Patterson and Ridgway, Certified Public Accountants. In their report they state that the Balance

INSTITUTE OF THE AERONAUTICAL SCIENCES, INC.

Statement for the fiscal year October 1, 1946, to September 30, 1947

Consolidated Balance Sheet and Operating Statement

ASSETS

General Fund Assets:		
Cash on Deposit and Petty Cash		$ 14,697.81
Accounts Receivable—Net		9,417.96
Advances on Contracts		32,768.68
Deposits and Prepayments		8,158.39
Furniture and Fixtures		5,000.00
Investment Accounts:		
Benefactor Membership Fund:		
U.S. Treasury Bonds		52,345.60
Reserve Fund:		
U.S. Treasury Bonds		174,000.00
Daniel Guggenheim Park (Assessed Value—$454,450.00)		1.00
Books, Prints, Models, Medals, etc.		1.00
Aeronautical Index		1.00
Total General Fund Assets		$296,391.44
Restricted Fund Assets:		
The Thurman H. Bane Award Fund:		
Cash on Deposit		$ 1,400.00
The Sherman M. Fairchild Fund:		
U.S. Treasury Bonds	$ 25,654.40	
Cash on Deposit	(170.91)	25,483.49
The Paul Kollsman Fund:		
U.S. Treasury Bonds		69,000.00
The Vernon Lynch Award Fund:		
U.S. Treasury Bonds	3,000.00	
Stocks	14,260.00	
Cash on Deposit	2,446.28	19,706.28
The Minta Martin Aeronautical Fund:		
U.S. Treasury Bonds and Stocks	512,907.96	
Cash on Deposit	5,175.85	518,083.81
The Sylvanus A. Reed Award Fund:		
U.S. Treasury Bonds	13,000.00	
Cash on Deposit	303.68	13,303.68
The Lawrence Sperry Award Fund:		
U.S. Treasury Bonds	13,000.00	
Cash on Deposit	59.18	13,059.18
New York Building Maintenance & Reserve Fund:		
U.S. Treasury Bonds	110,000.00	
Building and Property	212,916.74	
Cash on Deposit	2,023.76	324,940.50
Los Angeles Building Fund:		
U.S. Cert. of Indebt.	106,000.00	
Building (in process) and Land	90,498.61	
Cash on Deposit	137,264.94	333,763.55
San Diego Building Fund:		
Building (in process)	3,492.00	
Cash on Deposit	163,551.58	167,043.58
Total Restricted Fund Assets		$1,485,784.07

LIABILITIES, FUNDS, AND UNEXPENDED INCOME

General Fund:		
Accounts Payable	$ 11,264.79	
Deferred Credits to Income (Dues & Subscriptions)	34,647.41	
Withholding Taxes	1,819.75	
Reserve	174,000.00	
Unexpended Income:		
Balance September 30, 1947	74,659.49*	
Total General Fund Liabilities and Unexpended Income		$296,391.44
Restricted Funds:		
Principal of gifts and unexpended income (See Assets)		
Total Restricted Funds Liabilities		$1,485,784.07

Statement of Income and Expenses—General

INCOME		
Dues (less subscriptions)	$128,864.74	
Entrance Fees	4,505.00	
Interest on Investments	7,892.18	
Donors and Miscellaneous	1,054.83	
Excess of Income over Expenses:		
Journal of the Aeronautical Sciences	2,926.67	
Aeronautical Engineering Review	2,328.36	
Total Income		$147,571.78
EXPENSES		
Administrative and Clerical Salaries	$ 81,147.51	
General Office Expenses—Net	47,868.35	
Excess of Expenses over Income:		
Library Costs	18,180.59	
Total Expenses		147,196.45
Net Unexpended Income for the Period Ending September 30, 1947		$ 375.33

Detail of Journal and Review Income and Expenses

Review

INCOME		
Advertising Revenue	$ 68,921.46	
Subscriptions	15,331.04	
Total Income		$ 84,252.50
EXPENSES		
Editorial and Clerical Salaries	30,288.50	
General and Publication Expenses	51,635.64	
Total Expenses		81,924.14
Excess of Income over Expenses (See Institute Income)		$ 2,328.36

Journal

INCOME		
Subscriptions	$ 27,504.84	
Reprints—Net	157.14	
Total Income		$ 27,661.98
EXPENSES		
Editorial and Clerical Salaries	$ 4,549.95	
General and Publication Expenses	20,185.36	
Total Expenses		24,735.31
Excess of Income over Expenses (See Institute Income)		$ 2,926.67

* Several adjustments were made in the Surplus Account. They consisted of extraordinary nonrecurring expenses incurred during the fiscal year 1946–1947, which could not be construed as part of the normal operating expenses of the Institute, and the establishment of additional reserve accounts, as follows: Retirement and termination salaries $12,483.00; a study by Dr. Th. von Kármán in connection with the College for the Advanced Study of the Aeronautical Sciences, $4,000.00; Provision for Doubtful Accounts Receivable, $1,295.00; and a provision for Prepaid Review Subscriptions, $1,900.00.

Newly Elected Members to the Institute Council

Eastern Area

R. G. Robinson, Assistant Director of Aeronautical Research, N.A.C.A.

A. J. Thieblot, Chief Engineer, Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation.

Central Area

Major General F. O. Carroll, Director of Research and Development, Air Materiel Command, U.S.A.F.

C. Kenneth Razak, Head of Aeronautical Engineering Department, University of Wichita.

Western Area

Jack Mason, Wind Tunnel Manager, Consolidated Vultee Aircraft Corporation.

George S. Schairer, Staff Engineer, Boeing Airplane Company.

Council Members

Rex Beisel, Vice-President, United Aircraft Corporation.

William Bollay, Technical Director, Aero Physics Laboratory, North American Aviation, Inc.

Charles H. Colvin, Consultant.

Leroy R. Grumman, Chairman of Board of Directors, Grumman Aircraft Engineering Corporation.

L. B. Richardson, Vice-President, Curtiss-Wright Corporation.

Sheet and related statements of income and expenses fairly present the financial position of the Institute at September 30, 1947, and the results of operations for the fiscal year ended that date.

BURDETTE S. WRIGHT, *Treasurer*

Director's Report, 1947

IT IS VERY GRATIFYING to be able to report progress in all Institute activities during 1947. In spite of the fact that it was a year of general contraction for the aviation industry, the Institute more than held its ground on all fronts.

Most important of all, our financial position is sound. The Institute wound up its fiscal year, September 30, in the black (*see* Treasurer's Report), and the cost of operations for the 1st Quarter of the current fiscal year (ending January 1, 1948) is well under the budget that was approved by the Council in October.

Membership

Although there was a certain turnover, our regular membership increased by over 200 during the year. The number of active Sections went up from 13 to 17 and Section meetings from 72 to 92. Our Student Branch activities showed a marked increase, with 13 new Branches and with over 3,000 Student Members enrolled. The following tables prepared by the Secretary show the comparative standing over the past 2 years.

I.A.S. MEMBERSHIP—3-YEAR COMPARISON

	Jan. 1, 1946	Jan. 1, 1947	Jan. 1, 1948
Honorary Members	18	20	18
Honorary Fellows	18	19	21
Fellows	166	173	179
Associate Fellows	533	556	577
MEMBERS	1,704	2,119	2,781
Associate Members	321	329	405
Technical Members	3,264	3,263	2,728
Totals	6,024	6,479	6,709
Student Members	1,035	1,655	3,300
Totals	7,059	8,134	10,009

SECTIONS AND STUDENT BRANCHES

	December 31, 1946	December 31, 1947
Number of Sections	13	17
Number of Section Meetings	72	92
Number of Members in Sections	4,166	4,734
Number of Branches	38	51
Number of Branch Meetings	210	277

There has been no letdown in requirements for membership; if anything, the membership committee is scrutinizing qualifications more carefully than ever. It is definitely the policy of the Institute to maintain the quality of members at the highest possible level in each grade. There is no indication, however, that the saturation points have been reached for any grade. There are still many highly qualified people who are not members of the Institute. Many of them are being attracted to membership by increased activities by the Sections.

Meetings

The meetings during 1947 were well attended and set a high standard for the future. The change in locale for our Fifteenth Annual Meeting from Columbia University to the Hotel Astor in New York was wholeheartedly approved by the members, and we plan to continue similar arrangements in the future. The meetings schedule for the year was as follows:

Fifteenth Annual Meeting, January, New York, N.Y.
Aircraft Propulsion, March, Cleveland, Ohio
Personal Aircraft, May, Detroit, Mich.
Annual Summer Meeting, August, Los Angeles, Calif.
I.A.S.-R.Ae.S. Joint Meeting, September, London, England
Military Aviation, November, Dayton, Ohio
Wright Brothers Lecture, December, Washington, D.C.

An outstanding innovation during the year was the Joint Meeting with the Royal Aeronautical Society in London. This has been covered in the President's Report. It was extremely successful and discussions are now under way for a return engagement in the U.S. in the near future.

Several I.A.S. field trips were conducted during 1947, as follows:

May	U.S. Naval Aircraft Factory	Philadelphia and Johnsville, Pa.
August	Air Force Base	Muroc, Calif.
November	Wright Field	Dayton, Ohio

To observe local Section activities, the Director and Secretary and other officers of the Institute attended local Section meetings during the year in Philadelphia, Hagerstown, Washington, Toronto, Detroit, Dayton, San Francisco, Seattle, and Baltimore.

Publications

All publications were improved continuously during the year. The changes in editorial policy which went into effect during 1946 are beginning to bear fruit. Improved services to members through the furnishing of preprints and reprints under the Sherman M. Fairchild Publications Fund were effected. In general the scope of all publications has been expanded.

Because of high costs, both the JOURNAL and REVIEW were cut in volume during the early part of the year, but an appreciable expansion of both was contemplated in the 1948 budget and such expansion is under way. The advertising revenue of the REVIEW showed a forward trend during 1947, and the prospects for 1948, although not phenomenal, are definitely on the healthy side.

The CATALOG situation has been reviewed, and the 1948 CATALOG is now in the process of publication. The revenues were not up to predictions made last spring, but by taking advantage of all possible economies in printing and processing, costs have been worked down to the point where the 1948 CATALOG will be published on a break-even basis.

Reprints and Preprints.—During the course of the year, Mr. Fairchild authorized an extension of the use of The Sherman M. Fairchild Fund to cover the publication of meeting preprints and reprints. A small amount of equipment (ozalid and contact printers) was installed during the year. A special accounting system has been set up to handle income and outgo with respect to the Fund. This unit is being used as an experimental project to determine the most economical way to handle highly specialized technical papers on a limited distribution basis. An administrative Committee for the Fund has been appointed, including Sherman M. Fairchild, Charles H. Colvin, and the Director of the Institute.

Library Services

The usage of the Library expanded on a noticeable scale. A table showing 1947 Library statistics follows:

LIBRARY SERVICES
1947

Loans	2,197
Photostat Articles Supplied	287
Readers	805
Telephone Calls for Information	793
Books Added	1,276
Bound Periodicals Added	318
Total Volumes in New York and Los Angeles Libraries	34,970

Work is continuing on the cataloging of the Library and its contents. During the course of the year a large amount of material was received and cataloged from Air Technical Intelligence at Wright Field. William A. M. Burden added approximately $10,000 worth of books and other publications to the In-

stitute's library. The work of the Library was coordinated with the REVIEW, and it was also tied in closely with the Standard Aeronautical Index.

Standard Aeronautical Index

The most important project undertaken by the Institute during the year was the Standard Aeronautical Index. A contract was negotiated with the Air Materiel Command under which the Institute is developing a standard index system for the cataloging of all aeronautical technical information. This work has progressed very satisfactorily under the direction of Leslie E. Neville, who took over the management of the project in April, 1947. A staff of twelve people is involved—three of whom are on the West Coast and one in Dayton. Periodic reports have been furnished the Air Materiel Command. We have been given assurance that satisfactory progress is being made, and negotiations are under way to extend the contract into 1949.

General

The Aeronautical Museum is open to members during weekdays and is open to the public 2 days a week. Notable additions during 1947 included the Burden-Tissandier Collection of aeronautical furniture and objets d'art and an addition to the Heinmuller air-mail stamp collection. For maximum protection to the Institute's Museum, the Holmes Electric Protective System has been installed in the building.

In January, 1947, James L. Straight took over the duties of Manager, Western Region, with headquarters in Los Angeles. During the year he has been active in all I.A.S. affairs from Seattle to San Diego. His work is proving invaluable in maintaining close liaison between the western activities and the National Headquarters.

During the time the Director was in Washington with the President's Air Policy Commission, the work of the Institute went forward without interruption, thanks to the excellent performance of the Institute staff. All members of the staff carried extra loads during that period. Without their complete cooperation it would have been impossible for the Director to undertake both assignments at the same time.

S. PAUL JOHNSTON, *Director*

I.A.S. General News

T. P. Wright to Direct Cornell Research Foundation

Theodore Paul Wright, whose resignation as Civil Aeronautics Administrator was accepted by President Truman in January, was named President of the Cornell Research Foundation and a Vice-President of Cornell University. An Honorary Fellow and Past-President (1938) of the Institute, Mr. Wright's main responsibility as President of the Foundation will be administrative supervision of the Cornell Aeronautical Laboratory at Buffalo.

▸ **In Washington Since '41**—Named Assistant Chief, Aircraft Section, Office of Production Management in 1941, he has been continuously in Washington administrative posts ever since. Later Mr. Wright was appointed Assistant Chief, Aircraft Section, of the War Production Board, and still later became Director of Aircraft Resources Control Office, W.P.B. He was named to the post of C.A.A. Administrator in the fall of 1944.

Before going to Washington, he had a 20-year career in aeronautical engineering and administrative experience with the Curtiss Aeroplane & Motor Company and later with its successor, Curtiss-Wright Corporation. He was Vice-President of Engineering of Curtiss-Wright when he entered Government service.

▸ **Developed Curtiss Tanager**—Mr. Wright's best-known engineering work probably is the development of the Curtiss Tanager, a plane that won the Daniel Guggenheim Foundation's first prize of $100,000 in a 1929 competition. He also aided in the development of many civil and military aircraft.

New Cornell Research Head: *Resigned as Civil Aeronautics Administration chief, T. P. Wright has accepted the post of President of Cornell Research Foundation. In addition, he was named a Vice-President of Cornell University. Principal duties will be administrative supervision of the Cornell Aeronautical Laboratory.*

As C.A.A. Administrator, Mr. Wright is credited with certain policies of civil aviation regulation, including the following:

- Liberalizing physical requirements for pilots.
- Setting up an advisory committee on scheduled flying.
- Appointing large numbers of flight inspectors from industry to take over the main burden of inspection duties from C.A.A. general inspectors.

9 I.A.S. Members Receive Medal for Merit for War Work

Five Honorary Fellows, three Fellows, and one Member of the Institute of the Aeronautical Sciences were awarded the Medal for Merit by President Truman for their contributions to this country's aviation science during World War II. All served as wartime members of the National Advisory Committee for Aeronautics.

The death of Dr. Orville Wright, who with his brother Wilbur made the first powered airplane flight on December 17, 1903, prevented the presentation of the Medal by Gen. Carl Spaatz, Air Force Chief of Staff, who had planned to journey to Miami Valley Hospital in Dayton where Dr. Wright had been confined during his last illness.

Others honored were: Dr. George W. Lewis, Honorary Fellow and wartime Director of Aeronautical Research; Dr. Jerome C. Hunsaker, Honorary Fellow and present N.A.C.A. Chairman; wartime committee members Dr. Lyman J. Briggs, a Fellow, and Dr. George J. Mead, Honorary Fellow; William F. Durand, Honorary Fellow and expert in jet propulsion studies; John F. Victory, N.A.C.A. Executive Secretary, a Member; and Smith J. De France and Henry J. E. Reid, Fellows of the Institute and N.A.C.A laboratory chiefs.

Stress Analysis Society Meets in Pittsburgh May 27–29

The annual meeting of the Society for Experimental Stress Analysis will be held at the Roosevelt Hotel, Pittsburgh, Pa., May 27–29, 1948, it has been announced.

Inquiries should be addressed to the Society at P.O. Box 168, Cambridge 39, Mass.

Honors Night Dinner Highlights

"Foreign Policy for the Air Age" Offered by Chairman of Air Policy Commission Finletter; Doolittle Awarded Honorary Fellowship; Guggenheim Medal Presented to Lester D. Gardner by T. P. Wright

Preston R. Bassett and Award Winners: *The 1947 President of the Institute, Preston R. Bassett, who presented the annual awards at the Honors Night Dinner held in the Hotel Astor, January 26, is shown talking to the group of recipients in the Rose Room. Left to right: Lawrence A. Clousing, Chanute Award; H. K. Skramstad, co-winner of the Reed Award; Mr. Bassett; G. B. Schubauer, co-winner of the Reed Award; Comdr. Noel A. M. Gayler, Sperry Award; and Col. B. G. Holzman, Losey Award. Air Commodore J. Winfred Tice, Canadian recipient of the Jeffries Award, was not present when the picture was taken.*

SPEAKING AT THE INSTITUTE'S Honors Night Dinner at the Hotel Astor January 26, Thomas K. Finletter, Chairman of the President's Air Policy Commission, offered an appraisal, and the conclusions reached by the Commission, on the present state of our foreign policy to the nearly 1,000 distinguished guests comprising leading aeronautical scientists and industry experts. Title of his speech was "Foreign Policy for the Air Age."

▸ **Stresses Political Solution**—In it he stressed that one fundamental fact often overlooked was that "the only final solution to the problem of peace anywhere must be a political solution.

"Economic policies and military policies may help or hinder; but it is the political policies which are decisive," Mr. Finletter said. Excerpts of the speech appear on page 16 of this issue.

Preston R. Bassett, retiring President, opened the program with an address on the state of the aeronautical profession, striking a note of reasonable faith in the future. In addition, Mr. Bassett presented the Institute's Honorary Fellowship of the year to James H. Doolittle and Fellowships to the ten outstanding individuals elected in 1947. Also presented were five Institute awards for outstanding contributions to the aeronautical sciences. The Daniel Guggenheim Medal was presented to Lester D. Gardner by T. P. Wright, former Administrator of C.A.A.

In his address, Mr. Bassett mentioned four items that "broke new ground" during the year 1947 in connection with the Institute's activities.

- **The first** was the Standard Aeronautical Indexing System, a master scheme for indexing the "hundreds of tons of engineering and scientific reports."
- **Second item** was inauguration of special courses in advanced aeronautics sponsored jointly by Columbia University, M.I.T., and I.A.S., with Prof. Th. von Kármán giving a series of lectures and seminars at Columbia and M.I.T.
- **Third** was the first joint meeting of the Royal Aeronautical Society of England and the Institute in London last September.
- **Fourth and last item** was the selection of S. Paul Johnston, I.A.S. Director, as Executive Director of President Truman's Air Policy Commission.

▸ **Northrop Inducted**—As the final official duty of his Presidency of the Institute, Mr. Bassett passed "the gavel over to Jack Northrop," whom he characterized as one who "makes things interesting—give him a routine job, and it becomes exciting."

Responding with words of praise for his predecessor, Mr. Northrop offered a vote of thanks to Mr. Bassett for his highly capable work for the Institute while its 1947 President.

▸ **One Honorary Fellowship**—Only one Honorary Fellowship was awarded in 1947—there being no foreign Honorary Fellow elected in the past year. So far, only 15 Americans, including Mr. Doolittle, have been given this recognition, the highest honor that can be bestowed by the American aviation industry. The total now stands at 22, there being seven British Honorary Fellows.

Election of Fellows and Honorary Fellows is by secret ballot among the American Fellows of the Institute. Only two Honorary Fellows—one American and one foreign—may be selected in any one year. Fellowships are restricted to ten American and ten foreign recipients per annum.

With the addition of ten Fellows elected in 1947 (see page 6, Vol. 7, No. 2, February, 1948, AERONAUTICAL ENGINEERING REVIEW), there are now 154 American, and 34 foreign, Fellows, totaling 188.

Also presented by Mr. Bassett were five of the six annual awards sponsored by the Institute. These were reported in the preceding issue of the REVIEW. The sixth, The Thurman H. Bane Award, established by R. H. Fleet, was presented at the Annual Summer Meeting in Los Angeles last August.

A special event, the presentation of the Daniel Guggenheim Medal to Lester D. Gardner, founder of the Institute, by T. P. Wright, who recently resigned as C.A.A. Administrator to direct the Cornell Research Foundation, followed the announcement of the five award recipients.

Sponsored by three societies—the American Society of Mechanical Engineers, the Society of Automotive Engineers, and the Institute—who take turns in the annual presentations, the Medal had been awarded to Major Gardner early last year by a board of 21 members consisting of former recipients of the Medal and representatives of the three societies.

Six More Division Headings Accepted at S.A.I. Meeting

Sectional headings for six additional divisions of the Standard Aeronautical Index were accepted at a mid-January meeting of the S.A.I. Finalization Board at Index Headquarters, Institute of the Aeronautical Sciences Building, New York.

The new section headings were based on coordination contacts with approximately 200 aeronautical specialists and 100 existing indexes in the fields of Aerodynamics, Stress Analysis and Structures, Airplane Design, Propellers, Fuels and Lubricants, and Ordnance and Armament.

▶ **278 Specialists Contributed**—This work was included in the coordination activities of the Standard Aeronautical Index staff to which 278 specialists contributed during the past 10 weeks preceding the conference.

Among those present at the January 16 conference were Lt. Col. A. A. Arnhym, Chief, Air Documents Division, Chairman; E. W. Robischon, Special Consultant; Carl Elliott, Assistant to Colonel Arnhym; Leslie E. Neville, Director, S.A.I.; and Ned M. Thorne, Dayton Representative of the S.A.I., Secretary. S.A.I. staff members acting as project coordinators for these divisions were: R. M. Woodham, Administrator; Max Sokol, Project Engineer; Harris F. Reeve, Techfnical Assistant; and Keith Brown, Librarian.

▶ **S.A.I. Already in Use**—In opening the conference, Colonel Arnhym explained that the S.A.I. Divisions already were in use in the experimental phase of the Air Technical Index, which is now under way.

The 13 Divisions so far finalized are:

Guided Missiles (1)
Aerodynamics (2)
Power Plants, Rocket (4)
Power Plants, Jet & Turbine (5)
Power Plants, Reciprocating (6)
Stress Analysis & Structures (7)
Materials (8)
Instruments (9)
Airplane Design & Description (10)
Propellers (11)
Fuels & Lubricants (12)
Ordnance & Armament (22)
Installations, Underground (32)

S.A.I. Finalization Board Ratifies Six More Headings: *At a meeting of the Standard Aeronautical Index Finalization Board in mid-January, six additional Division headings were ratified. Chairman of the Board, Lt. Col. A. A. Arnhym, presided. Reading clockwise from left: Keith G. Brown, S.A.I. Project Librarian; Ned M. Thorne, S.A.I. Dayton Representative, Secretary; Carl Elliott, Assistant to Colonel Arnhym; Ernest D. Robischon, Special Consultant; Colonel Arnhym; Leslie E. Neville, Director, S.A.I.; Ruland M. Woodham, Administrator; Harris F. Reeve, Technical Assistant; and Max Sokol, Project Engineer.*

Gifts to the Institute Collections

The Republic Aviation Corporation sent models of the XF-12 photo-reconnaissance airplane and the P-84 Thunderjet fighter through the courtesy of Ken Ellington. The first aileron of sandwich construction, flown on a U.S. Navy trainer, was given by Skydyne, Inc., through the courtesy of Melville K. Weill.

Issues of the JOURNAL OF THE AERONAUTICAL SCIENCES, Volumes 3 through 10, were received from Eugene W. Norris.

The Eclipse-Pioneer Division of Bendix Corporation added a number of *N.A.C.A. Wartime Reports, Technical Notes, Technical Memorandums,* and *Technical Reports* to its previous generous gifts, through the courtesy of Miss Mildred M. Baker.

The Laboratorio di Aeronautica of the Politecnico di Torino sent 16 of its reports through the courtesy of Prof. M. Panetti. Several of its publications were received from the Groupement Français pour le Développement des Recherches Aéronautiques (G.R.A.) in Paris. A complete file of the *Technical Notes* of the Meteorology Department of Transcontinental & Western Air, Inc., was sent by that company through the courtesy of G. A. Browne.

Bound volumes of its *ACA Reports* for 1944 and 1945 were sent by the Australian Council for Aeronautics. The Division of Radiophysics of the Australian Council for Scientific and Industrial Research gave five of its *Radiophysics Reports* on the operational aspects of air-line trials.

LeRoy V. Coburn added air baggage and air freight labels and other aeronautica to his previous gifts. Herbert Schoenfeld added a number of new air labels to his previous gifts. Mrs. Bella C. Landauer added clippings and a kerchief with balloon and airship designs to her previous generous gifts.

Dr. Otto Kallir added an air-mail catalog to the large number he had previously given.

Additional gifts were received from the American Road Builders Association, British National Physical Laboratory, British Supply Office, California Institute of Technology, Goodyear Tire and Rubber Company, International Civil Aviation Organization, Professional Race Pilots Association, Radio Corporation of America, U.S. Civil Aeronautics Administration, and Carl Gustav Wachtmeister.

Corporate Member News

• **American Overseas Airlines, Inc.,** boosted operations last year, flying a total of 174,500,000 passenger-miles and showing an increase in passengers carried of 82 per cent over 1946. An increase of 62 per cent was made in cargo and mail carried. Passengers totaled 63,570, while cargo and mail totaled 2,860,000 lbs.

• **Beech Aircraft Corporation** reported a net income after taxes of $319,858 for quarter ending December 31. This compares with a loss of $116,851 for same period in 1946.

• **Bell Aircraft Corporation** began delivery on its motorized wheelbarrow, "Prime Mover," in January.

• **Boeing Airplane Company's** first YC-97A Stratofreighter, transport counterpart of the B-50 Superfortress, took to the air January 28 from Boeing Field on its maiden flight. Design gross weight of the transport is 135,000 lbs.; wing span, 141 ft.; and length, 110 ft.

• **Eastern Air Lines, Inc.,** hung up what is believed by EAL officials to be fastest speed ever made by a commercial air line when one of its Constellations flew nonstop, Miami to New York, in 2 hrs. 41 min. 30 sec. With 55 passengers and a five-man crew, Eastern's Connie reached a top speed of 565 m.p.h. and averaged 421 m.p.h. . . .Contracts have been let by EAL totaling $500,000 for materials for company's $1,000,000 Line Maintenance Building to be erected this year in Miami as an addition to its Operations and Maintenance Base.

• **Fairchild Engine & Airplane Corporation** reported a net income of $86,999 for the 5 months ended May 31.

• **General Electric Company** was presented with seven awards in recognition of G-E-designed aircraft jet engines, which have established an equal number of air-speed records, including the world's official mark of more than 650 m.p.h. The awards were presented by the National Aeronautic Association.

• **Jack & Heintz Precision Industries, Inc.,** has manufactured (at press time) 1,000,000 fractional horsepower motors since May, 1946.

• **North American Aviation, Inc.,** reported production of the AT-6 advanced trainer is to be started soon in Holland—fifth foreign country to build one of the company's trainers—under a licensing agreement. Other nations licensed to produce North American trainers are Sweden, Canada, China, and Brazil.

• **Northwest Airlines, Inc.,** plans to build an international traffic office in Washington, D.C., at 1510 H. Street, N.W. Work is expected to be completed this month. New quarters will accommodate a ticket office, district traffic manager's office, conference room office for traffic staff, reservations center, and publicity office.

• **Pan American World Airways System** flew 62,000 passengers across the Atlantic in 1947 compared with 27,300 in 1946. Of the 1947 total, 39,700 were westbound and 22,300 eastbound. . . .Pan Am's general traffic offices of its Latin American headquarters have been moved from the Aviation Building in Coconut Grove to new, larger headquarters at 1851 Delaware Parkway, across the street from the division's executive offices.

• **Republic Aviation Corporation's** employment now stands just under 6,000. Production of P-84 jets is about one-plus per day.

• **Solar Aircraft Corporation** realized a profit of $395,147 on sales totaling $7,207,074 for the year ending October 31, 1947.

• **Trans World Airline** carried 66,384 international passengers in 1947, gain of 103 per cent over previous year. Express and freight increased 220 per cent to 3,016,245 ton-miles, and mail was up 75 per cent to 3,273,501 ton-miles.

• **United Air Lines, Inc.,** in December flew a total of 74,411,200 passenger-miles and 1,872,764 ton-miles of freight and express. Cargo tonnage was up 20 per cent over same month in 1946. . . .New weather forecasting service to analyze and appraise flying conditions across its system will be established in Denver soon.

Sections and Branches

Baltimore Section

David P. Samson, Jr., *Secretary*

In the absence of the Chairman, Joel M. Jacobson, Vice-Chairman G. N. Mangurian presided at the January 23 meeting. Attendance was 78.

▶ **Committee Appointments**—In the business session preceding the speaker of the evening, the committee appointments were announced. The chairmen were as follows:

(*Continued on page 85*)

Silicone News

DC

DC Silicones Help Maintain High Performance Standards of Portable SoundScriber

DC 33 Silicone Grease permanently lubricates portable SoundScriber gear drive. DC 4 Compound damps vibrations in playback head.

A portable recording machine that can be used in your car is obviously subject to operation in extremes of temperature. Yet turntable speeds are critical. The SoundScriber Corporation, New Haven, Connecticut, has solved this problem with a sealed gear drive mechanism permanently lubricated with DC 33 Silicone Grease.

Here are the benefits reported from the use of DC 33 Silicone Grease in the drive mechanism:

1. It eliminates the need for relubrication; DC 33 does not evaporate or dry out.
2. DC 33 retains its consistency and provides effective lubrication at temperatures ranging from —95° to 300° F. It therefore permits the motor to start easily and operate satisfactorily when cold; it does not thin out and leak through bearing joints at high temperatures as do other greases or oils having a low enough torque at low temperatures.

And here are the advantages of DC 4 Silicone Compound as used in the playback heads of all models of the SoundScriber:

1. It effectively damps the moving coil of this playback uniformly at any temperature—giving an "oil damping" effect without requiring elaborate sealing devices.
2. DC 4 is inert to most organic materials. It can, therefore, be used in direct contact with the rubber supports in the playback heads.

Dow Corning Silicone Products are notably indifferent to temperature changes. They possess other unique properties that may be even more useful to you. We've had nearly five years' experience in the commercial production of Silicone Greases, Fluids, Resins, and Silastic*. Telephone the branch office nearest you for engineering assistance, or write for Catalog S1-4.

*TRADEMARK FOR DOW CORNING SILICONE RUBBER

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
New York • Chicago • Cleveland • Los Angeles
In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London

Dow Corning
FIRST IN SILICONES

In Memoriam

ORVILLE WRIGHT

What the Wright Brothers did, every one of us knows well. All possible adjectives have been used in every possible combination to describe their early struggles, their perseverance, the final triumph of December Seventeenth, Nineteen Hundred and Three. Nothing that could be said here could add to that story. It is now History.

But as we sat in the little church in Dayton where Orville Wright's body lay amid the banked flowers, our thoughts went more to what the Wright Brothers *were*, than to what they had accomplished. In a very real sense, Orville and Wilbur were aeronautical scientists. They could not draw upon any accumulated store of aeronautical knowledge. They could not profit by the mistakes of others. What they knew of the problem of mechanical flight they had to work out from scratch. They had to find out for themselves.

Their approach was always scientific. Trial and error obviously played some part, but, more often than not, they approached each problem with the utmost objectivity, reasoning it out step by step, resorting to experimental methods when factual data were lacking. Without formal scientific education, they were scientists and engineers in the truest sense. The best of us, with all our schooling, may still profit by their example.

All Dayton stood in silent tribute as Orville joined Wilbur in the little cemetery on the hill-top. He was honored by the world for what he had done, but he was loved by his home town for what he was—a quiet, simple citizen, a good neighbor.

The final words spoken in the church were not new. They were said of another great American, but they were equally apt there. They were echoed by all of us out of the fullness of our hearts—"NOW HE BELONGS TO THE AGES."

ORVILLE WRIGHT—First Honorary Fellow of the Institute. (Portrait by Lewis Eugene Thompson as displayed at the Institute's New York Headquarters.)

Finletter

addresses

Honors Night Dinner

Excerpts from the address by the Chairman of the President's Air Policy Commission* at the Hotel Astor on the evening of January 26 on

"FOREIGN POLICY for the AIR AGE"

"War is still an institution to be recognized—for all our protests to the contrary—as the final way of settling disputes between nations. To be sure, it is our avowed policy to work for the elimination of war through the United Nations. But we have not gotten very far. . . . The current scientific revolution . . . has made and is continuing to make war so horrible that no civilization can stand it. In any future war both sides will lose. . . . It is the ignorant who speak lightly of the possibility of conflict, who still want to play the game of international diplomacy in 19th century terms. . . .

"Clearly our military policy and our diplomatic policy are interdependent. Whether we need or do not need a strong military establishment must depend on the state of the international scene and on the responsibilities of the United States in that scene. . . .

* * * * * *

"There are two ways in which we could go about this business of seeking peace. One would be to take an enormous chance and disband our Army, Navy, and Air Force, and hope by the very force of our moral courage to persuade the rest of the world to join with us in a crusade for peace. . . . It would be the way to do it if we were a nation of saints and martyrs and not of men and women who have concern for the safety of ourselves and our families. . . .

"But it is not a good thing or a safe thing to do now. One reason is the sharp tension which exists between Russia and the United States. But more important even than that is the technology of modern warfare, the technology which requires so much time to design and build the weapons of modern war and, because of the violence of these weapons and the speed with which they can be delivered, gives such a great advantage to a nation which is prepared for war.

* For a condensed summary of the Report of the President's Air Policy Commission, see page 34.

"So the Commission decided that a strong armament policy was needed as a shield to protect the nation while it worked on its policy of producing a peaceful world. We believed that a United States which showed that it was willing and able to defend itself if anyone attacked it would be more likely to persuade Russia to join with it in making a peaceful world than a United States which was disarmed, or inadequately armed. We believed also that a strong United States would be likely to hearten those friends of the United States throughout the world who want to preserve the supremacy of the Individual against the State, and would help to keep them on our side. . . .

* * * * * *

"We did not, however, claim that a strong armament policy by the United States was the whole answer to the problem of peace. . . . Our armaments policy, indispensable as it is, is largely the negative side of our policy for peace. Our armaments policy must, by its nature, be temporary. . . . We must make haste with our politics for peace, for we cannot long endure a world bristling with atomic and biological weapons, carried by long-range jet bombers traveling at near the speed of sound. . . .

* * * * * *

"We are following two lanes in our foreign policy for peace. The first is economic. We realize that Western Europe and Asia cannot remain on our side if they are starving. We therefore have decided to send to these areas food and materials by which they can build up their ability to produce.

"The purpose of this economic policy is in part charitable. It is part of our tradition to want to help those

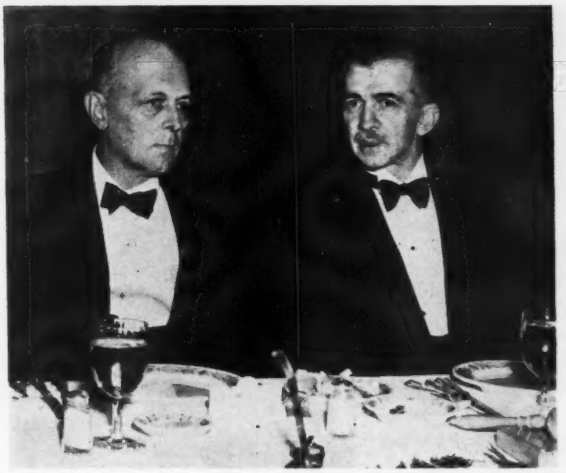
who are in distress. There is also a political purpose . . . to keep Western Europe and China on our side in the cold war.

"This statement of the case should be enough to dispose of the argument that the Marshall Plan and the strong Military Establishment which we have recommended are to some extent alternatives. They are not. They are complementary. A strong Military Establishment will not of itself produce peace. A Marshall Plan will not of itself produce peace. Nor will the two of them together produce peace. But they will help. And both must be carried out fully. If a second-best Air Force is almost as bad as none, so a second-best reconstruction program is almost as bad as none. . . .

"On the other hand, our military expenditures are in a measure dependent on the success or failure of the Marshall Plan. The recommendations in our Air Report were on the assumption that the Marshall Plan would be accepted at its full $6.8 billion for the period through June 30, 1949. If the Marshall Plan were to be rejected, I believe that the rate of build-up of the Air Establishment which we have recommended would have to be sharply increased. . . . The spectacle of a Western Europe, hungry and unable to produce enough for its needs, as would be the situation if the Marshall Plan were rejected, would greatly weaken our strategic position and cannot be tolerated. . . .

* * * * * *

"But, on the other hand, the voting of the Marshall Plan appropriations will not justify us in reducing our military appropriations. . . . The only final solution to the problem of peace anywhere must be a political solution. Economic policies and military policies may help or hinder; but it is the political which are decisive. . . .



Thomas K. Finletter (*left*) with retiring I.A.S. President Preston R. Bassett at Honors Night Dinner.

Until there is such a political solution, any reduction in our military establishment would be folly. . . . But in our political efforts we have made no steps forward since V-J Day. We are further away from political solutions now than we were in August, 1945. This is by no means all the fault of the Russians. We in the United States simply are not putting our backs into this phase of our work.

* * * * * *

"Now for the first time, nearly three years after V-E Day, we are beginning to face up to this question. The simple truth is that we dare not turn Germany loose as an independent state. The risk is too great. Only by making Germany part of a larger political unit which

she would not be able to dominate would it be safe for us or our Allies to withdraw the troops of occupation. In short, nothing less than European Union—A United States of Europe—can make it safe for us to withdraw our troops from Germany.

* * * * * *

"But even a political solution of Europe would not solve the problem of peace. It would not be a world solution to the problem of war....

"The simple fact is that we will never be able to disarm until there is a world political solution which will eliminate war as a recognized institution for the settlement of disputes between nations. A political solution of Western Europe would be a great step forward. But it would still recognize the Balance of Power. And the Balance of Power, because of the very fact that it recognizes *Power* and not *Law* as the final authority, also recognizes war as the final way of settling international disputes....

"The inescapable fact is that the United States must keep an increasingly powerful military establishment until such time as a world-wide rule of law administered by the United Nations is established. And the future of the United Nations is now hanging in the balance of events that must be decided within the next few months....

"Two immediate issues will put our attitude toward the United Nations to a early test. At the moment the northern borders of Greece are violated by the neighbors of Greece in open defiance of the United Nations.... And soon the British will withdraw from Palestine, leaving that area open to civil war.... These are two test cases which will forecast the direction in which the United Nations will go. If it handles these, there will be ground to hope that UN, with the United States taking the lead, as it must, will go on to become the guardian of the peace of the world under a régime of law administered by it.

"If these hopes seem Utopian, let us point out that precisely such a development is contemplated by the United Nations Charter. The machinery is all there. What is needed is that the United States ask that a General Conference of the members of the United Nations be called under Article 109 of the Charter and that the United States propose at this Conference a general treaty covering the armament of the United Nations and the corresponding disarmament of the member states, the elimination of the veto in the Security Council, and amendments to the Statute of the International Court of Justice which will enable the United Nations to enforce a world law against war and against national armaments directly on individuals throughout the world.

* * * * * *

"I know all the arguments against this. I shall deal with only one of them—namely, that all this is impractical because Russia will not go along.

"My answer is that it is time for the showdown on this business of organizing the world for peace.... And, when I say a showdown, I mean a showdown with ourselves as well as with Russia. For there is the devil within as well as the devil without. We ourselves have not made up our minds that we want peace so badly that we will give up our tradition of strict nationalism and put all the chips on the international way of doing things of which the United Nations is the symbol and the instrument.

"We must do this. We must take a chance and try the United Nations way. The worst we can do is fail—and then only in part. For, even if Russia will not come along, the outcome of any such General Conference, if the United States really means business, would be to organize the Western World into a solid political bloc for peace. We could not, in such a case of partial failure, be able to disband or even reduce our military establishments. That we cannot do until all the world is united under one régime of law. But we would be able to use our air power and the rest of our military establishment, as part of a total force for peace of the Western World, in aid of a great principle....

"If our Air Report will be of any service to the country, it will be, I hope, to make it doubly clear that the present world political institutions and relationships are completely intolerable; that the United States must stop thinking in terms of what cannot be done; and that it must instead focus its entire foreign political policy on eliminating war as an institution of human affairs."

Among Those Present at Reception and Honors Night Dinner

(Top left) **J. S. McDonnell, James H. Doolittle, and Preston R. Bassett have no difficulty finding topics of mutual interest to discuss before the dinner.**

(Top right) **Included in the distinguished list of foreign guests and visitors are Col. R. Roos, Air Chief Marshall Sir Guy Garrod, and Group Captain P. G. Baskerville.**

(Left center) **Elmer Sperry and the Hon. John N. Brown hold a little private conversation during the reception.**

(Right center) **The ten I.A.S. Fellows for 1947 (whose individual pictures may be found in the February REVIEW are seated at a special table for the dinner.**

(Bottom left) **The outgoing and incoming Presidents of the Institute, Preston R. Bassett and John K. Northrop, compare notes at the Annual Meeting.**

(Bottom right) **T. P. Wright, displaying the Daniel Guggenheim Medal which he presented during the dinner, extends further personal congratulations to recipient Lester D. Gardner.**

Admiral Land

on

"A.T.A. Policy"

Excerpts from Luncheon Address at I.A.S. Annual Meeting, January 27.

"IT WAS WITH PARTICULAR GRATIFICATION that I accepted the invitation to address this meeting.... There might be some permanent advantage if you, on the technical side of the aviation industry, were given some insight into the broader problems of scheduled air transport and the way they are handled through the A.T.A.

"The domestic, local service, and international air carriers of the United States have total assets of some 650 millions of dollars. Ten years ago the total assets of United States air lines did not exceed 80 million dollars—which is about the depreciated value of the air planes owned by the four largest of our air carriers today.

"...I hope to give you, who develop and perfect the machines and equipment used in scheduled air transport, some conception of the considerations which influence our decisions and shape our policies as we go about our task of helping to chart a course for ourselves."

Air Lines Result of National Policy

"The phrase 'help to chart a course for ourselves' is used pointedly. For, though the air lines are private business and susceptible to success by reason of efficient management and good service, or to failure from bad management and poor service, nevertheless we are not entirely masters of our fate. We are the result of a national policy formulated by the Congress in 1938, by which the Federal Government has rigid regulatory powers over the economic and operational affairs of the scheduled air lines, so that they may be developed and maintained in a healthy, competitive pattern for their own good and the public welfare.

"Once it was established as a feasible and practical means of transportation, air transport grew at an astounding rate. The total mileage of domestic routes in operation grew from 8,200 in 1926 to 41,000 in 1940 and to 115,000 at present. Foreign and territorial routes operated by American companies grew from 152 miles in 1926 to 53,000 in 1940 and 175,000 miles today. Fifty-seven hundred passengers were carried by the air lines in 1926. Last year there were 13,000,000."

Heavy Demand Posed Needs

"As the nation emerged from the depression which gripped the world in the early '30s, the scheduled air-line industry grew with the rebounding energy of the American people.... The heavy demand for scheduled air transport posed several needs. One was for organization of the industry on a self-regulatory basis. Another was for recognition of the air-line companies as common carriers of passengers and cargo, therefore eligible for Government regulation. Another was for expansion of air-line service to fit the national requirements for air mail. Another was for development of civil aviation as an adjunct to national defense. Finally, there was the very apparent need for extension of Governmental aid while this complicated pattern was being worked out to permit the air lines to develop to their logical place in the nation's transportation scheme with the speed demanded in the public interest.

"The Air Transport Association is the cooperative industry organization composed of the United States flag air lines certificated by the Civil Aeronautics Board for service over regularly scheduled routes.

"In plainer words, A.T.A. is a trade organization, devoted to every industry-wide activity which will help to develop scheduled air transport."

Alertness Required for Self-Regulation

"Effective solution of a policy of self-regulation—or I should say self-solution of the industry's problems—

(*Continued on page 93*)

General Powers on "Design for Mass Production"

Excerpts from an Address Given at I.A.S. Luncheon, January 28.

"BOTH DURING AND SINCE THE WAR, the Air Force has been seriously concerned with costly difficulties encountered in production and maintenance of military aircraft.

"It is neither my desire nor intent to try to tell you how to design aircraft. However, the severity of production and maintenance problems has frequently had the effect of nullifying the advantage of superior design. These problems must be recognized, defined, and solved now, while we have the time to do it.

"Prior to the war aircraft were not mass-produced. During the war they had to be, and the tremendous expansion of the industry in less than 3 years attested to the fact that they could be."

Expansion Had Its Price

"However, the expansion was not without its price. Of necessity, effect was focused on the all-important objective of superior planes in sufficient numbers.

"As technical and operational requirements became more critical the aircraft grew more complex, and production and maintenance problems more acute. Rather than compromise functional operation or delay production by redesign, difficulties were overcome whenever possible by unstinting use of funds, resources, and man power.

"Fortunately we had enough of all three. Also, as it developed, we had enough of a fourth priceless ingredient in the cost of war—time.

"Since the productive capacity of this nation has twice been the undoing of well-planned aggression, it is a fair assumption that in the event of another emergency whatever else we may have, we won't have much time.

"With that thought in mind, it is essential that we profit by past experience without delay."

Time the Imponderable

"Since time is an imponderable which, in the American tradition, only the enemy can predict, the design engineer, the production engineer, and the maintenance engineer must combine their talents during the design stage.

"Without sacrificing functional characteristics necessary to ensure superiority, production and maintenance problems must be given consideration during the design stage in order to ensure that the advantage of superior design will not be lost through inability to produce in quantity or inability to keep the aircraft in service after it has been produced.

"As the design engineer reduces military characteristics to facts and figures, the production engineer can break the unit down into subassemblies which will permit greater utilization of unskilled personnel, lend themselves to more rapid fabrication, and above all reduce final assembly jig time. Furthermore, subassemblies minimize delays incident to redesign by localizing the effect of changes."

Maximum Interchangeability of Parts a Must

"Maximum interchangeability of parts and subassemblies is a must. It reduces the time required for replacement, reduces the size of inventories which must be carried, and reduces the likelihood of an otherwise complete aircraft being grounded for want of a single part.

"Incorporation of standard parts and fittings is another important factor in quantity production of aircraft.

"Tooling is another critical factor in the production sequence where savings in time could be realized through maximum use of subassemblies and standardization.

"And in this connection the matter of tolerances should be given careful consideration. Granted that fine tolerances are essential at many points, effort must be made to ensure that wherever possible throughout the aircraft structure unnecessary close tolerances are

(*Continued on page 93*)

Sixteenth Annual Meeting of the Institute of the Aeronautical Sciences—Part I*

ALEXANDER KLEMIN†
Aeronautical Consultant

THE SETTING OF THE INSTITUTE'S annual meetings is a splendid stage that never changes and where the play is performed only once. This year, more than ever before, it was a play worth attending. Nor could one complain of the attendance, though there were fewer executives present; the leaders of the aviation business are probably too busy facing the hardships of the times.

In the early days of the Institute, all its members were young, or comparatively young, and came to the Annual Meeting year after year. Now, today, the hand of time is seen more clearly, familiar faces disappear, by promotion to executive position, which is tolerable, or by death, which is sad. In the 1 week of the Annual Meeting there were lost forever to the Institute Orville Wright, the greatest of all aviation pioneers; Col. Virginius E. Clark, designer of the Clark Y and at one time so prominent as a leader in aerodynamics and airplane design; and Capt. Richard H. Depew, who attended the earlier events of the Meeting in apparently the best of health and whose name for nearly three decades been synonymous with the development of civil aviation in general and of private flying in particular. Some of the old timers who came once again were slightly disgruntled, not because new and younger men were reading the papers, as might well be expected, but because the younger men were revolutionizing the science of aerodynamics, presenting such novel ideas, and because the well-beloved "incompressible fluid" had become an out-of-date fiction. This sort of thing always happens in the history of science. Did not Lord Kelvin, one of the greatest mathematical physicists of the nineteenth century, say in his older years that he could see no utility in vector analysis? Looking at the strictly technical papers as a whole, one could see not only new ideas but greater mathematical complexity. The younger men start with more accumulated knowledge, and graduate studies are now the rule rather than the exception. European influence is strong in advancing our mathematical standards—the Nazis did us a good turn when they sent us the best of their scientists—and the more mathematical a paper the closer to European influence is its author likely to be, or to Chinese influence. We note in American aeronautics such names as Tsien, Chang, Wang, Wong, Yuan. Of course, for Chinese who master an alphabet of tens of thousands of letters and whose fathers passed

examinations lasting for weeks, matrices, tensor calculus, and the like are mere child's play.

Although those who attended the Sessions were for the most part technicians, the Sixteenth Annual Meeting was *not* solely concerned with technology. The engineers heard history when Thomas K. Finletter of the President's Air Policy Commission spoke of "Foreign Policy for the Air Age," because what the Commission advocates and the extent to which the President and Congress act upon its recommendations may spell national survival or doom, and they listened with approval and some regret when Dr. Hugh L. Dryden, Director of the N.A.C.A., took as his subject "Research Foundation of Air Power." They heard Rear Adm. E. S. Land, President of the Air Transport Association, promise a new, thoroughly integrated system of air traffic control that might conquer weather and all other operational difficulties. There was history also in the fact that we are passing from transonic to supersonic flight, and of the six papers in aerodynamics four carried in their titles the word supersonic. Aerodynamicists attack and begin to understand the theory of control and stability in supersonic flight and the theory of airfoils in their curious modern forms. Again, for the first time in the history of the Institute, a whole session was devoted to aerodynamics of the upper atmosphere. Missile designers study flight at such great heights that the air is no longer a continuum, that the behavior and speed of individual molecules have to be considered, and theory begins anew. And vehicle designers will soon give attention to the problems that already in-

* This covers the first 2 days of the Technical Sessions.

† Helicopter Editor, *Aero Digest*, and Editor, *Handbook of Aeronautical Engineering*.

trigue missile designers. Another sign of the times: papers in flight propulsion dealt with gas-turbine performance and the cooling of turbine blades. The reciprocating engine, useful still, no longer attracts research attention. The propeller remains in the forefront because of turboprops. Instrument designers discussed novel methods of measuring high exhaust temperatures and Mach Numbers. In the meteorological sessions there was also discussion of the upper atmosphere, and Mark Twain's remark that no one does anything about the weather becomes dated when serious workers spoke of juggling with snow or rain and making weather to suit man. The two main problems of the helicopter are reduction of vibration and improvement in stability, and the helicopter session gave promise of both. Not every session was glamorous, but every part of the meeting was solidly instructive as in topics such as passenger comfortization, sandwich construction, and landing-gear design. Whoever devised the program understood that it takes all sorts of men and things to make up the world of aviation and acted accordingly. Thus all visitors were satisfied, from the mathematical aerodynamicist to the air transport operator concerned with keeping planes flying safely above crowded airports, and since all the papers were sincere and well prepared, for what more could one ask?

Instruments

The Meeting began on a Monday morning, lasted 4 days and evenings, and justified its length because there were scarcely any "double events" and no scurrying from room to room by men interested in two or three sessions held simultaneously. Only on the very first morning did one have to choose between "Instruments" and "Rotating Wing Aircraft," and these are, after all, sharply differentiated topics.

The Instruments Session, whether by accident or intention, served as a keynote to the whole meeting, since it dealt with instruments for high-speed flight, for jet power plants, and for air traffic control.

Scientific instrumentation is a satisfying field where the designer has to be both a physicist and an inventor, and we can imagine how happy D. W. Moore, of Fairchild Camera and Instrument Corporation, must have been when he devised "A Pneumatic Method for Measuring High Gas Temperatures." Mr. Moore wanted to measure the temperatures of modern power plants that range from a maximum of perhaps 2,500°F. for turboprop installations to more than 8,000° for rocket propulsion systems, while afterburning in turbojets and ram-jets can give operating temperatures above 3,500°F. Two unconsciously humorous sentences deserve quotation: "It is well known that the turboprop engine cannot be safely operated without accurate measurement and control of combustion chamber temperatures. If these temperatures exceed certain limits, the power plant, as well as the air frame in which it is installed, may be destroyed." The difficulties to be surmounted were as great as the objectives were important. In jet work one can hardly use a conventional element such as a thermocouple. Protected against oxidation sufficiently to have service life, such an element will not respond quickly enough. Radiation produces serious errors at high temperatures; unburned or burned liquid fuel deposited on a thermocouple will ruin its accuracy. The ingenious Mr. Moore and his associates turned to the use of an orifice and the equations of gas flow. In the conventional use of the orifice, if temperature and differential pressures are known, gas flow can be calculated. In this new device, shown diagrammatically in Fig. 1, if the pressure, differential pressure, and a reduced temperature are known, we can compute the high temperature and subsequently calibrate for it. The operation is simple. A sample of the hot gases to be measured is drawn from the combustion chamber and passed through the first orifice. It is cooled to a measurable temperature and passed through a second orifice. With the orifice areas substantially constant, a neat, approximate equation follows:

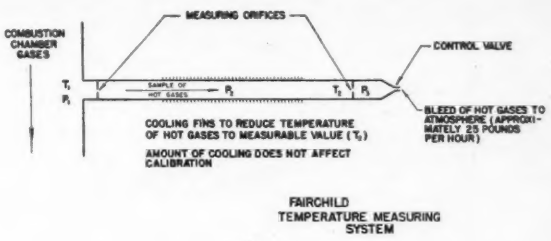

MEASURING ORIFICES
COMBUSTION CHAMBER GASES
CONTROL VALVE
SAMPLE OF HOT GASES
COOLING FINS TO REDUCE TEMPERATURE OF HOT GASES TO MEASURABLE VALUE (T_2)
AMOUNT OF COOLING DOES NOT AFFECT CALIBRATION
BLEED OF HOT GASES TO ATMOSPHERE (APPROXIMATELY 25 POUNDS PER HOUR)
FAIRCHILD TEMPERATURE MEASURING SYSTEM

FIG. 1.

$$T_1 = KT_2(P_1 - P_2)/(P_2 - P_3)$$

with the symbols as in Fig. 1. The principle once conceived, realization is simple. A pickup, a regulator for constant pressure drop across the second orifice, a device for multiplying the reading T_2 by the ratio of the pressure drops, were all a question of commercially available apparatus or of simple design. Errors are small, life is excellent, and as Mr. Moore says, "Since the pressure drop across the orifices is purely a function of the density and volume of the gas flowing through the system, the overall speed of response is very great."

Herbert Schaefer, Kollsman Division of Square D Company, described an instrument, a "Machmeter for High-Speed Flight Research," which is equally elegant and likewise based on principles of mathematics and physics, on abstruse equations. The Machmeter still has a family resemblance to the conventional air-speed indicator, a pitot tube is still the indispensable element, and the difference between the total or stagnation pressure in the pitot and the static pressure of the ambient atmosphere still provides the basic source for actuation of the instrument. But with today's subsonic flight speeds, the air has to be treated as compressible, the formula relating Mach Number and pressure differential has to be complex:

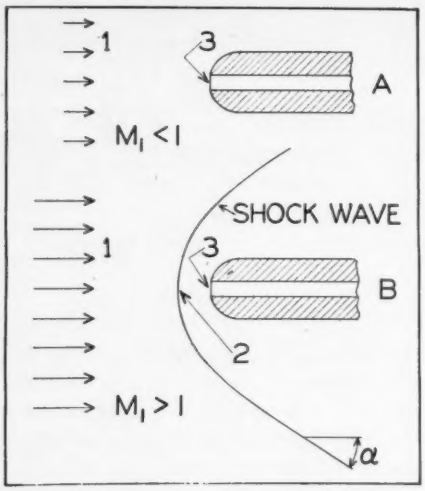


FIG. 2.

$$M_1 = \left\{ \frac{2}{k-1} \left[\left(1 + \frac{\Delta p}{p_1} \right)^{(k-1)/k} - 1 \right] \right\}^{1/2}$$

In supersonic flow the pitot tube creates a detached shock wave (Fig. 2), and theory must take into account the finite increase in pressure across the shock. Fortunately, the study of compressibility and shock antedates flight, and Mr. Schaefer reminds us that Lord Rayleigh as early as 1910 produced this attractive looking formula for the ratio of the stagnation pressure to the static pressure:

$$\frac{P_3}{P_1} = \left[\frac{2k}{kH} M_1^2 - \frac{k-1}{k+1} \right] \times \left[\frac{(k+1)^2}{4k} - \frac{k^2-1}{4k} \cdot \frac{1}{\frac{2k}{k+1} \cdot M_1^2 - \frac{k-1}{k+1}} \right]^{k/(k-1)}$$

where k is the usual ratio of specific heats and M_1 is the Mach Number. Is the scientific instrument maker daunted by these mathematical complexities? Not a bit of it. He simplifies the formulas, he notes with satisfaction that, while subsonic and supersonic formulas are different, the pressure ratio curves are continuous at $M_1 = 1.0$, and he proceeds to build complex, yet practicable, instruments that reduce these formulas to readable indications on a dial and that even take into account the variation of the speed of sound with altitude (as shown in the curves of Fig. 3). These instruments are complex, particularly when intended for supersonic use, but they are not overwhelmingly complex as the following quotation indicates: "A schematic diagram of the operation of the subsonic Machmeter is shown in Fig. 4. The stagnation pressure or pitot pressure p_3 is led into the open diaphragm, while the static barometric pressure P_1 is led into the inside of the airtight case of the instrument. The resulting movement of the open diaphragm, which is a function of the differential pressure Δp, by means of a lever arm rotates the first rocking shaft, which in turn rotates the

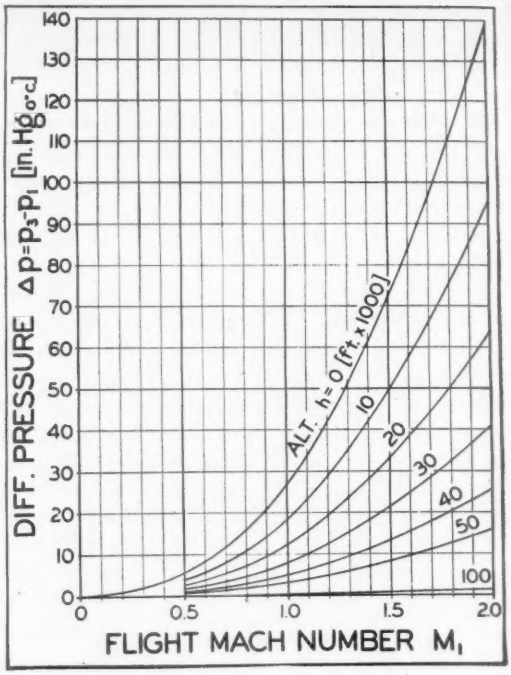


FIG. 3.

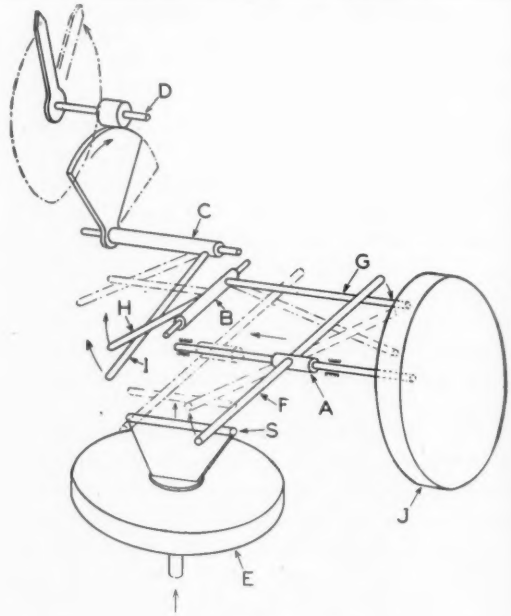


FIG. 4.

sector rocking shaft through a pair of levers. From this sector rocking shaft the movement is transmitted to the handstaff by means of a sector and pinion. The altitude correction is accomplished with an evacuated altitude diaphragm, which responds to the static pressure p_1. With increase in altitude—i.e., decrease in static pressure—this diaphragm expands and pushes the first rocking shaft to the left. This movement causes a shortening of the effective lever arm of the

sector rocking shaft lever, thereby changing the amount of rotation caused by the open diaphragm." The subsonic Machmeter is calibrated for a range of flight Mach Number 0.3 to 1.0 and a range of altitude from 0 to 50,000 ft. and an accuracy of ±0.02. There is not much difficulty in finding a proper location for measuring stagnation pressure with a pitot tube of conventional design. The static vent, normally placed on the side of the fuselage, offers more difficulty because of bow waves. Mr. Schaefer offers a truly ingenious solution. In the arrangement of Fig. 5 a shock wave would be created at the side that is beveled, while a Mach line, a very weak shock, would occur on the straight side of the knife edge. Thus, the bow wave of the conventional pitot would no longer upset the static pressure source.

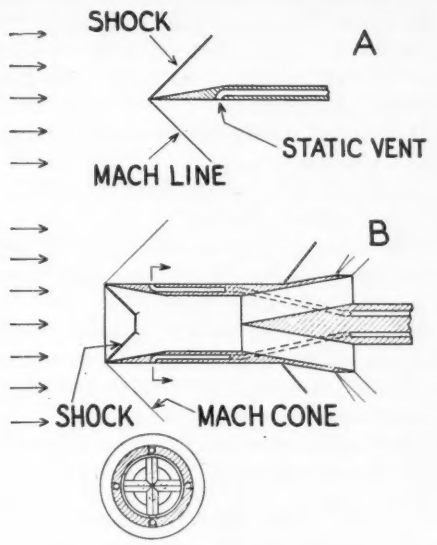


FIG. 5.

Flight Propulsion

As we said in our introduction, the reciprocating engine no longer holds high attention. Gas turbines and jets displace it. But propellers are as important as ever, and propeller designers have to meet new and difficult problems in the modern power plant. That was one of the lessons of the Flight Propulsion session, among many others.

Arthur N. Tifford (Westinghouse Electric Corporation) started the session with his paper on "The Application of Gas Turbines to Aircraft." To read his paper is to realize how rapidly the modern aircraft power plant has gained complete acceptance. Mr. Tifford presented some thoughts on this subject before the Philadelphia Section of the Institute on January 7, 1947, and his findings at that time were startling. Now they are truisms, though none the less valuable, and his presentation of the "inverse power law" is likely to be a classic. Mr. Tifford focused his attention on range and, as a result of masterly analysis, came to the following conclusions:

"There is a maximum achievable range for each weight class of turbojet aircraft. It is 3,300 miles for 60,000-lb. aircraft using current jet engines and slightly greater for larger aircraft.

"The use of an adjustable exhaust area will not increase the maximum achievable range of current turbojet aircraft but will make possible the realization of 'high-altitude' ranges at low altitudes.

"A comparison of the performance of aircraft powered by reciprocating, turboprop, and turbojet engines indicates that, for a maximum cruising altitude of 35,000 ft., (a) aircraft with top speeds below 335 m.p.h. achieve their maximum range when powered by reciprocating engines; (b) aircraft with top speeds above 610 m.p.h. achieve their maximum range when powered by turbojet engines; (c) aircraft with top speeds in between these two limits in general achieve their maximum range when powered by turboprop engines; (d) aircraft designed for extreme ranges greater than 9,500 miles have highest top speeds when powered by reciprocating engines; (e) aircraft designed for extreme ranges less than 2,500 miles have highest top speeds when powered by turbojet engines; (f) aircraft designed for an extreme range between 2,500 and 9,500 miles have highest top speeds when powered by turboprop engines in general."

How did Mr. Tifford arrive at this excellent summary of the situation? Mainly by the use of this "inverse power law" and the concise formula that represents it:

$$\text{S.F.C.} = K/V^n$$

where

- S.F.C. = the specific fuel consumption
- K = a function of the component efficiency levels, the type of engine, and the altitude
- n = 0.85 for the average current turbojet engine
  = 0.1 for the average current turboprop design
- V = airplane speed

TABLE 1

Values of n and K for Several Declassified Turbojet Engines

Engine	n	K at Sea Level	K	Altitude	K	Altitude
Rolls-Royce Nene I	0.83	185	170	15,000	162	30,000
General Electric I-40	0.84	195	176	25,000	174	45,000
German BMW-003	0.84	240	221	20,000	207	30,000
German Jumo-109-004-B	0.87	285	269	20,000	261	30,000

The data of Table 1 emphasize the significance of this formula and the fact that turbojets improve so greatly in fuel consumption with both altitude and

speed. Together with the following remarks they give a fine background for power-plant selection:

(1) At speeds above 715 m.p.h. at sea level and 650 m.p.h. at 35,000, turbojets have higher propulsive efficiency than propellers.

(2) At take-off and climb, low propulsive efficiency will always penalize turbojets.

(3) Turbojets achieve minimum specific fuel consumption at nearly maximum output.

(4) The output of turbomachines falls off with altitude at a rate in between that of unsupercharged and supercharged reciprocating engines.

(5) For turboengines flying at constant true speed, the minimum specific fuel consumption decreases with altitude until the tropopause. Higher than the tropopause, it is independent of altitude.

(6) The output of turbomachines may be represented by the equation output

$$\alpha\sigma^{3/4} \text{ (up to the tropopause)}$$
$$\alpha\sigma \text{ (beyond the tropopause)}$$

(7) While the rated thrust output of turbojets is fairly constant independent of cruising speed, the rated equivalent power output of the turboprop increases approximately as the cruising speed raised to one-fourth power.

Our brief summary of Mr. Tifford's paper underlines one point. There is a definite sphere of action for the turboprop. Mr. Tifford is a power-plant designer. Frank W. Davis, Consolidated Vultee, an airplane designer, supported Mr. Tifford in his paper on "Problems of Gas Turbine Propeller Combination" by a specific comparative analysis. The problem was to design a single-seater escort fighter, the XP-81, to accompany the B-29's. For 1943, the requirements were stiff: operating radius of 1,250 miles; cruising speed of 250 m.p.h. at 25,000 ft.; high speed of 500 m.p.h.; combat ceiling, 37,500 ft.; two-engined reliability. The choice of power plant was between the General Electric TG-100 turboprop and the Pratt & Whitney R-2800 reciprocating engine. Comparative charts show that the use of the TG-100 gave (1) a smaller airplane; (2) lower take-off gross weight; (3) lower airplane weight at start of combat; (4) less weight of fuel consumed at cruising altitudes above 25,000 ft. Mr. Davis' views, based on actual design experienced and supported by the chart of Fig. 6, are valuable and encourage the use of the turboprop. But that part of his paper which deals with the difficulties of the power control system is even more valuable for all concerned. Mr. Davis describes the TG-100 control as: The pilot's throttle controls the displacement of a variable displacement fuel pump. This control is modulated through suitable means by three other factors: (1) a centrifugal type topping governor set for maximum engine r.p.m.; (2) a temperature sensitive topping governor set for maximum tail temperature; (3) a pressure sensitive device that compensates for altitude and air-speed changes. And on the basis of actual experience, ground and flight testing,

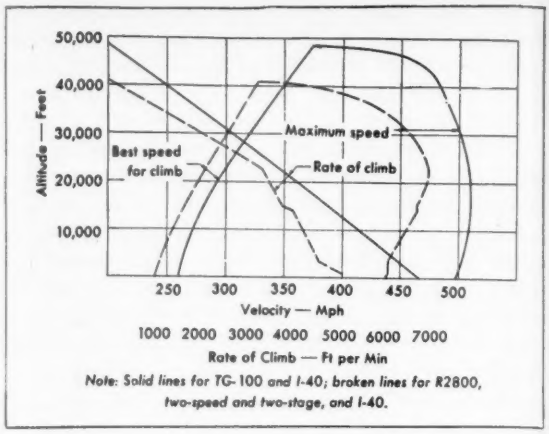

50,000
40,000
30,000
20,000
10,000
Altitude — Feet
Maximum speed
Best speed for climb
Rate of climb
250 300 350 400 450 500
Velocity — Mph
1000 2000 3000 4000 5000 6000 7000
Rate of Climb — Ft per Min
Note: Solid lines for TG-100 and I-40; broken lines for R2800, two-speed and two-stage, and I-40.

FIG. 6.

here are his recommendations that none can afford to neglect:

"At the time these flights with the TG-100 were made, no propeller specifically designed for gas turbines was available. The use of propellers and governors designed for reciprocating engines proved to be unsatisfactory in several respects. Since that time, much work has been done on the governing and control problem by those carrying on turboprop development, and solutions may have been found for many of them. However, the following suggestions may still be in order.

"New standards of propeller balancing should be developed in order to take full advantage of the inherent smoothness of the gas turbine engine.

"The requirements for rate of pitch change should be restudied in order that the engine may be protected from excessive torque loads due to too fast pitch change while, at the same time, providing adequately fast build-up of thrust after sudden throttle applications. In this regard, it is felt that pilots' comments obtained from tests on reciprocating engines may be misleading if applied directly to the gas-turbine problem.

"The observed shortcomings of the 'constant-speed' propeller governing principle give rise to the speculation that a governor responding to torque might prove more desirable than one responding to r.p.m.

"Because of the high windmilling drag of a turboprop, emergency feathering should be automatic. Furthermore, it should be done at the fastest rate that will not produce excessive shaft torque under any flight condition. This calls for a variable feathering rate that, along with automatic feathering, might tie in well with the torque sensitive governor suggested above.

"A temperature sensitive topping governor should be developed which would operate sufficiently fast to prevent exceeding turbine temperature limits under any conditions.

"Service life of turbine wheels, ease of starting, and other operational characteristics must be improved."

Mr. Tifford in his discussion of aircraft gas turbines was conservative and did not project gas turbines into

the future. His analysis would have been much more optimistic had he allowed for the much higher inlet temperatures and thermal efficiencies that engineers are seeking. Herman H. Ellerbrock in his paper "N.A.C.A. Investigations of Gas-Turbine Blade Cooling" summarized the possibilities of higher inlet temperatures very well. The gas turbine may improve to some extent in flow capacity and efficiency, but thermodynamics show that, for a given airflow capacity, the greatest benefits will come from higher temperatures. Let us quote Mr. Ellerbrock: "By raising the turbine inlet temperature to 2,000°F., from a temperature of 1,500°F., the specific thrust of the engine may increase 32 per cent, although at the expense of a 7 per cent increase in specific fuel consumption because of loss of propulsive efficiency at the high relative jet velocities. At the same time, the specific weight of the power plant would be reduced approximately 30 per cent. For the turbopropeller type engine at optimum power compressor pressure ratio, an increase in turbine inlet temperature from 2,000° to 3,000°F. would result in a 5 per cent reduction in specific fuel consumption with a 57 per cent increase in specific power output. Furthermore, comparison of the 3,000°F. turbopropeller power plant having an optimum power compressor ratio with present-day designs shows a reduction of 50 per cent in specific fuel consumption and an increase of over 200 per cent in the specific output." These advances are worth seeking. What limits inlet temperatures?—the turbine blades themselves which have to resist high temperatures superimposed on high gas velocities. There are three lines of attack: better heat-resistant alloys; the use of protective ceramics; and, probably the most promising, the cooling of the blades. It is with this last method of improvement that Mr. Ellerbrock was concerned. We are fortunate that the N.A.C.A. is a semi-independent Government agency that can quickly seek out timely problems and truly help industry—just as in this problem of cooling turbine blades. There are three plausible methods: (1) rim cooling in which a cooling medium acts on the rim of the turbine disc and conduction cools the blades; (2) hollow-blade air cooling (which the Germans have used with success); and (3) liquid cooling with liquid circulating through passages in the blades and discs. Theoretical analysis is immensely difficult. It is fairly easy to calculate rate of heat transfer across simple flat plates in laminar flow; it is more difficult when the flow is turbulent. In the case of turbine blades, there are turbulent flows to consider; it is not permissible to postulate one-dimensional flows. There are factors such as blade inside convection heat-transfer coefficients; blade outside heat-transfer coefficients; coefficients for radiation from nozzles to the blades; effective gas, metal, and coolant temperatures; etc. Exact analytical solutions are almost impossible. The N.A.C.A. scientists have used theory and dimensional analysis and have reached some tentative theoretical conclusions: (1) Rim cooling will allow little increase in temperature but will lengthen blade life; (2) hollow-blade air cooling should permit 500°F. temperature increase, and 650°F. increase when an insert is placed in the hollow blade; (3) last and best, with liquid cooling, high melting point alloy steel turbines should be able to operate at turbine-inlet temperatures near to those attainable with present-day fuels. These scientists are now proceeding to experiment. They have given much thought to apparatus, and, because blade cooling in the actual turbine offers so many difficulties, they will work at first on static cascades of blades and check against data from rotating cascades. It is a foregone conclusion that turbine designers will learn much from their experiments.

It is difficult to match the propeller with a power plant because of the many parameters. There are many methods, and they are all difficult and time-consuming. Joseph P. Grandfield, Emmert T. Jansen, and James L. Cooley, all of United Aircraft, in the remaining paper of the Flight Propulsion Session presented a "Method for Handling the Performance of a Propeller and Its Match to a Power Plant." Abstracting is difficult in this valuable paper. We shall be content with the authors' summary:

"A method is proposed for handling the match of a propeller and a power plant. It has been devised for the purpose of giving a rapid, accurate, and simple solution to performance problems involving propellers and power plants. In addition, as a secondary aim, attention has been given to a form of presentation which offers a framework for, and a picture of, data on power plants and propellers regardless of the source of the basic material—flight test, tunnel test, computation, or other correlation.

"The proposed method depends on a single-graph presentation of a propeller's performance characteristic, a single-graph presentation of a power-plant's performance characteristic, the use of transparent graph paper, the use of logarithmic coordinates, and the use of standard familiar engineering parameters."

Air Transport

Because the Institute is so concerned, and rightly so, with the physical sciences and design problems of aeronautics, it does not neglect air transport, to which three sessions were devoted and in which the selection of subjects was suitably broad. From the topical general public point of view, the most interesting paper was that presented by Jerome Lederer, of Aero Insurance Underwriters, whose subject was "Loss Prevention Programs in Civil Aviation," with the clarifying subheading "The Present Status of Safety and an Inquiry into Yardsticks Used to Measure It." Mr. Lederer sadly recalled that in the spring of 1947 there was a series of air-line accidents. Then came a Congressional air safety investigation and next the President's Board of Inquiry into Air Safety. They focused the public's attention on flying safety and made it perfectly clear that the survival of civil aviation depends on safety. There is no better man in the United States than Mr. Lederer

to answer the first all-important question: "How Safe Is Aviation?" He presented several yardsticks, the first of which lay in the question, "How many miles must I ride as a passenger before I'll be killed?" The answer for 1946 would have been about one chance in 560 million passenger-miles or 0.18 per 100 million passenger-miles. That seems to be a good record in the absolute sense, and no reasonable person would hesitate to ride in a railroad train on such a basis. But how does aviation safety stand in a relative sense; how does it compare with other methods of transportation? The National Safety Council gives the answer, shown in Table 2.

TABLE 2

Average Death Rate 1944–46 per 100 Million Passenger-Miles

Passenger Automobiles and Taxis	2.70
Busses	0.19
Railroad Passenger Trains	0.21
Scheduled Air Transport	1.7

In the relative sense, then, safety of travel by bus is about the same as by railroad; by air, eight times as dangerous as on the railroads, but 60 per cent better than traveling in a passenger automobile or taxicab, and no one hesitates to travel in an automobile. Mr. Lederer summarizes his conclusions from statistics thus: "Therefore, it is fair to conclude that the magnitude of safety achieved by the air lines would be fully acceptable to the public if the public did not receive a distorted picture of air-line safety from the press." The sad record of early 1947 disregarded, it is perfectly certain that Mr. Lederer is right. Newspapers please note. But Mr. Lederer, though satisfied, is not complacent, and he advocates a number of things to increase air-line safety:

"Air-line accidents due to fires in flight or structural failure are important but of a transitory nature. The outstanding factor in producing fatal or potentially fatal air-line accidents over a period of years is the error made in approach and landing during poor weather conditions. If this factor were eliminated, about 40 per cent of fatal or potentially fatal air-line accidents would go with it. Further improvement will result in the future by advances in methods for selecting personnel, refinement in training methods and maintenance of pilot proficiency, the establishment of improved systems to obtain closer control over the quality of performance, and fundamentally a recognition by designers of the fact, easily proved, that pilots and mechanics are human. Being human they are subject to fatigue, strain, forgetfulness, and other causes of error in action. Designers must give as much emphasis to the human factors as to performance and structural integrity."

When it comes to private flying, the speaker was realistic and pessimistic, as the following remarks show. "Even on the basis of the best record, if there were as many personal aircraft as automobiles, we would have about 300,000 fatal accidents per year and kill 500,000 people... The accident rate in personal flying is not of a magnitude that the public would accept if they knew how bad it was. It is the reverse of the air-line picture where the accident rate is good but the public looks askance." Is there any way of improving the situation? Yes, of course:

"In personal flying, the fatality record can be reduced by almost 45 per cent if the stall spin can be averted. This and a campaign against low flying to reduce collisions with trees, mountains, and other objects on the ground would attack another 25 per cent of the fatal accidents occurring in personal flying. The rerating of instructors and the general tightening of training procedures appear very necessary. As in Air Transport design, the design engineers should recognize the problem of safety created by human limitations and carelessness."

Comfort is second only to safety in securing patrons for the air lines, and whatever may be their short-

Bernard L. Whelan, *General Manager, Sikorsky Aircraft Division, United Aircraft Corporation; Chairman of the Rotating Wing Aircraft Session.* **Speakers at Air Transport Design Symposium:** *(From left to right)* *P. A. Roush, D. L. Loughborough, both of Physical Research Laboratory, The B. F. Goodrich Company; William Littlewood (Chairman), Vice-President—Engineering, American Airlines, Inc.; K. R. Jackman, Chief Test Engineer for Consolidated Vultee Aircraft Corporation; and J. C. Lederer, Chief Engineer of Aero Insurance Underwriters.* **R. W. Young,** *Vice-President of Engineering, Wright Aeronautical Corporation, Chairman of the Flight Propulsion Session, listens while* **Arthur N. Tifford,** *Westinghouse Electric Corporation, discusses gas turbines.*

comings in the matter of safety, our operators and manufacturers are always at work improving the passenger cabin. K. R. Jackman, Consolidated Vultee, confirms this view in his discussion of "Research Toward Greater Air-Line Passenger Comfort." The paper is based on a hundred references and much original work and is encyclopedic in character, so that we can only note its high spots. Consolidated Vultee believes above all in quiet cabins and restful chairs and in a laboratory approach to both problems. In the last 2 years, research on the ground by means of a portion of an airplane fuselage or "Sound Cabin" has brought much progress and avoided much expensive flight-testing. Mr. Jackman feels that judging the noise intensities in aircraft by means of "overall" levels is not conclusive and recommends that the acoustical comfort level of a plane should be judged by the average intensity measured in the "Hiband Octave" of 1,200–2,400 cycles per sec. Here is a useful tip to people working in this field: The author believes that pulsating, intermittent noises, squeals, chattering are more irritating to passengers than more intense but steadier noises. He has carried out much research in soundproofing materials and presents definite conclusions.

The reduction of noise by the exhaust augmentor is noticeable both to cabin passengers and to airport personnel. As much laboratory research has gone into seating as into acoustical research and in the author's abstract we read:

"The development of the current lightweight Convair double passenger seat is described, together with the part played by the laboratory research in Fiberglas cushions toward greater seating comfort. The use of such test aids as the 'Dynamic Cycler' to accelerate life tests on seats and cushions, the 'Single and Multiple Indentors' for spring-rate determination, and the 'Vibrindex' and 'Ridometer' in ride characteristic identification is discussed."

From passenger comfort it is natural to turn to a study of De-Icers. There are people who believe that the exhaust gas heating of leading edges, the prevention of ice formation, is now preferable to deicing of the rubber boot variety. But The B. F. Goodrich Company boot De-Icer has done so much for air-line operation in the past, it is so near to perfection in the present that the "Study of Wing De-Icer Performance on Mount Washington" by D. L. Loughborough, H. E. Greene, and P. A. Roush was heard with much attention. It is impossible to improve on the author's summary:

"Three seasons of testing full-scale De-Icers on Mount Washington have proved that this location is a suitable place for testing such products. Experiments can be performed comparatively rapidly at low cost in frequent, severe icing storms that duplicate those encountered in flight. Care is required in interpreting the data to avoid weighting the results arising from the low wind velocity too heavily.

"The observations in slightly more than 600 icing storms have given the first statistical evaluation of service performance. Laboratory predictions concerning the advantages of silicones as ice adhesion depressants and the use of extremely small inflatable tubes for transmitting the pneumatic stresses to the ice-rubber interface have been borne out.

"A De-Icer with these two improvements removed practically all of the ice in 90 per cent of the icing storms met on Mount Washington as compared to 45 per cent for a satisfactory commercial model. The standard used in these ratings is severe.

"Build-up of ice most often occurs during the formation of very light feathery rime for which the tensile strength of the ice is insufficient to transfer stresses high enough to break the adhesive bond. This type of ice occurs more frequently on the mountain than it would in flight largely because the wind velocities are lower."

Air Transport Symposium Panels: (*From left to right*) *Vernon I. Weihe, Air Transport Association of America; C. Towner French* (*Chairman*), *Vice-President, Eastern Region, Institute of Navigation and Washington Representative, Fairchild Camera & Instrument Company; Nathan Braverman, Assistant Chief Engineer, Communications & Navigation Laboratory, Wright Field; Captain A. S. Born, U.S.N., Office of Chief of Naval Operations; Sir Robert Watson-Watts, Scientific Advisor on Telecommunications Air Ministry, Great Britain; Scott Flower, Pan American World Airways System; Raymond B. Maloy, Flight Engineering Division, C.A.A.; Melvin N. Gough, Chief Flight Research Division, Langley Memorial Aeronautical Laboratory, N.A.C.A.; George Trimble, Chief Aerodynamicist, The Glenn L. Martin Company; and Raymond D. Kelly* (*Chairman*), *Superintendent of Engineering Development for United Airlines, Inc.*

The papers presented at the Institute, like the two previously reviewed, generally record the results of research and experimentation. James L. Anast, All-Weather Flying Division of the Air Materiel Command, broke precedent because he spoke of what is yet to be done with an "Automatic Flight Controller." The A.M.C. has designed and assembled a prototype "Automatic Flight Controller" that receives a flight plan and exercises aircraft control functions to give completely automatic flight in elementary form a great step forward toward all-weather flying. Mr. Anast was modest in stressing that the Controller is still in the experimental stage, but it already has to its credit the automatic flight recently made from Stephenville, Newfoundland, to Brize Norton, England—surely a remarkable achievement. The paper is of real interest because it lists and describes the main elements of this ambitious device. Here is its *basic definition:* automatic pilots and automatic radio compasses adapted to automatic flight control; ancillary electromechanical systems to reproduce the action of a human pilot in receiving flight information; equipment integrated into a system that allows preselection of flight parameters; and automatic sequential control of the aircraft to produce the flight that is preselected.

A Master Sequence Selector determines the Schedule of the flight. This is essentially a multichannel, multipole electrical switch that advances in position when its energizing circuit is actuated. It completes a number of electrical circuits and holds them closed until an actuation is received. Control of the automatic pilot and other components is a function of the Master Sequence Selector, and the flight schedule progresses automatically by the use of sensory instruments that actuate the Master Sequence Selector at the end of each phase of the flight. The basic component of the Controller is the automatic pilot that provides a three-axis attitude reference, flux valve erection of the directional gyro, electrically actuated rate displacement servo-control of the control surfaces, automatic trim-tab operation, barometric altitude control, automatic coordination of turns and coupling between the A.A.F. Instrument Low Approach System and the automatic pilot. In addition to the automatic pilot, various devices are used to translate basic flight information into actuating and control signals. Signals are introduced into the attitude circuits of the automatic pilot, by the error, as read by the flight instruments, from the preselected flight plan. We can only list some of the other components, and let their names hint at their purposes: (1) magnetic head selector; (2) radio compass controller; (3) automatic engine-control system; (4) pitch attitude selector; (5) constant air-speed control; (6) landing-gear and flap control; (7) altitude control; (8) altitude sensor; (9) air-mile counter; (10) localizer and glide-path sensor. All this sounds complicated, but there have been achieved automatic landing, vertical control, and automatic navigation. Surely they are worth some trouble if we seek all-weather flying?

Rotating Wing Aircraft

The papers on the Machmeter and on high-temperature measurements showed how scientific and mathematical modern instrument designers have to be. The Session on Rotating Wing Aircraft showed that helicopter engineers must have similar abilities. Mechanical ability and intuition simply will not suffice because of the complexity of this field.

Apart from the question of costs, an industrial problem, the three problems that helicopter engineers must solve before all others are rotor fatigue, vibration, and stability (with which control is inextricably joined) and probably in this order. Whoever planned the Session must have been of the same opinion because the titles of the papers were, in this order: (1) "The Testing of Rotors for *Fatigue* Life" by Jonathan Winson, Prewitt Aircraft Company; (2) "Reduction of *Vibration,*" by Walter Gerstenberger, Sikorsky Aircraft; (3) "Chordwise and Beamwise Bending *Frequencies* of Rotating Blades," by Gabriel Horvay, General Electric Company; and (4) "The Helicopter *Control* Rotor," by Joseph Stuart, III, United Helicopters.

The problem of rotor fatigue comes first because safety is paramount and because the helicopter is probably the safest of aerial vehicles until a blade pulls out, when it becomes the most dangerous. To evaluate fatigue stresses in a rotor is a more difficult matter than in a fixed wing, first, because in forward flight bending moments fluctuate and even change sign in the course of a cycle, and second, because there are encountered abrupt changes in section and corresponding stress concentrations. An ordinary whirl test is not sufficient because it does not simulate fluctuations; flight tests of sufficient duration to establish fatigue would be inordinately expensive. Mr. Winson, in his well-presented paper, discussed the simulating of fluctuating stresses by applying a second harmonic control in the ground test and supported his idea by careful calculation and analysis. In a blade that is carefully balanced chordwise, three stress-producing quantities are important; they are: centrifugal tension, bending moment in the plane of flapping, and bending moment in the plane of rotation or "in-plane" moment. The condition of interest is that of forward flight at a speed above cruising. In such a flight condition, the steady centrifugal stress combines with the fluctuating stress due to bending moment in the plane of flapping to cause stresses and fatigue and the design condition in the bending plane at mid-span. On the other hand, the fluctuating stress due to the in-plane moment reaches a maximum and combines with the centrifugal stress to give the design condition in the plane of rotation toward the root of the blade. Vertical hinges and dampers used in flapping blades complicate the analysis, so does the fact that the blades are not rigid. Mr. Winson's study nevertheless shows that, in a whirl test with rotational speed, collective pitch, and second harmonic control, enough parameters are available to simulate flight conditions adequately and also that the

test could readily be made long enough to give the desired number of stress reversals. Of course, such a method of fatigue testing itself needs, first of all, correlation of stresses with strain-gage measurements in flight.

Mr. Gerstenberg's able investigation of vibration reduction must have been a great disappointment to many helicopter people. Helicopter vibration is a matter of common-sense guesses, of difficult and incomplete calculations, followed by lengthy, disappointing, and expensive flight tests, and ended by only partial success. Here, said the constructors, is a paper by the vibration specialist of the oldest helicopter group in the United States. He will, they hoped, say the last word and produce some fine cut-and-tried rules that faithfully followed will guarantee success. Mr. Gerstenberg showed fine knowledge of the subject, wrote a masterly paper, but offered instead of a simple solution a long and difficult process. The author first introduced a graphical method for determining aerodynamic forces. He used methods paralleling Wheatley's derivation but found the cyclic pitch change necessary to provide a certain rotor tilt and eliminate thrust moment at the root of a flapping blade by strip theory, graphical methods, and approximations. The method has the disadvantage of some untried assumptions and the advantage of coping with any rotor blade however complex in design. Once carried through, it gives by Fourier analysis the steady, first cosine, first sine, and second cosine components of all the aerodynamic forces. Thus the exciting aerodynamic forces are known.

The second step in the long process of vibration analysis is to determine the dynamic excitations—namely, the Coriolis forces due to flapping of the blade, and the vibratory forces introduced by oscillation of the blade about a vertical hinge, all with the aid of reasonably easy formulas. Here is a valuable remark: "The general conclusion is that, although appreciable blade stresses may result because of the damper restraint, the force transmitted to the ship remains small unless the hinge offset and the damping coefficient are large enough to change appreciably the phase and magnitude of the blade motion about the drag hinge. For normal configurations with the first and second harmonic excitations many times the pendular natural frequency of the rigid blade, the damping force is secondary to the inertia force in determining blade motion."

Then Mr. Gerstenberg considers blade response. He adopts, very logically, as generalized coordinates the normal modes of vibration. He uses a "pinned-free" beam for a hinged rotor and for the odd harmonics of a see-saw rotor. The modes of a cantilever beam are used for a rigid rotor and for the even harmonics of a see-saw rotor. The normal modes are the solutions of certain differential equations with the exciting force equal to zero and numerical methods such as an extension of Stodola's method to include the effect of centrifugal force.

The final step in the vibration analysis is to determine the response of the fuselage due to the transmitted loads. Generalized coordinates are again used, with simplified assumptions such as treating the fuselage as a separate item.

Thus a complete method is offered which relates exciting forces, aerodynamic and dynamic, to the elastic properties of the airplane. Once this is done, it is possible to avoid resonance and reduce vibratory phenomena generally. But if the method is complete, it is by no means simple.

The paper includes some nonmathematical reflections on isolation and on the smoothness required which must be quoted:

"Paradoxical though it seems, the problem of isolating in the presence of a large steady force independent of the size of the mass to be isolated is simplified when the mass is heavier. The heavier mass allows a greater spring rate for a given frequency, thus reducing the steady deflections. Thus, isolating the engine and rotor is more efficient than isolating the rotor alone and eliminates the necessity of providing separate isolators for the engine. Another approach is to isolate the cabin where the steady forces are considerably smaller, except for the landing condition with a nose wheel. For this condition the supports may bottom, allowing a conventional landing strut to function as usual. The use of such a device is desirable if comfort considerations warrant the additional weight increase, but in the past more conventional arrangements have been a satisfactory compromise between weight and comfort when a fully articulated three-bladed rotor was employed.

"The question is invariably raised, 'How smooth is a smooth ship?'

"This question has been answered many times by investigators in all types of transportation. The magnitude of the vibration and the variation of the magnitude with frequency sufficient to cause discomfort vary widely. The tendency in fixed-wing aircraft is to prescribe a maximum acceptable amplitude. In view of the low frequency of the rotor excitations in helicopters, cognizance must be given to the fact that an individual feels the acceleration rather than the amplitude in this frequency range. Although difficult to attain in present-day helicopters, the author believes that a helicopter that has accelerations of less than ± 0.1 g in the frequency range up to 20 cycles per sec. and amplitudes less than ± 0.002 in. for higher frequencies can be considered smooth. This limit is plotted on a log-log system of coordinates, which give amplitude, velocity, and acceleration simultaneously plotted versus frequency."

It was appropriate that Gabriel Horvay, General Electric Company, should, at this stage, present his calculations of "Chordwise and Beamwise Bending Frequencies of Rotating Blades" and thus help to implement Mr. Gerstenberg's method. The author related the higher natural frequencies of a nonrotating blade to the fundamental frequencies and expressed the frequencies of the rotating blade in terms of the nonrotating frequencies and the speed of revolution. He determined these frequency relations for a 23-ft. Mc-

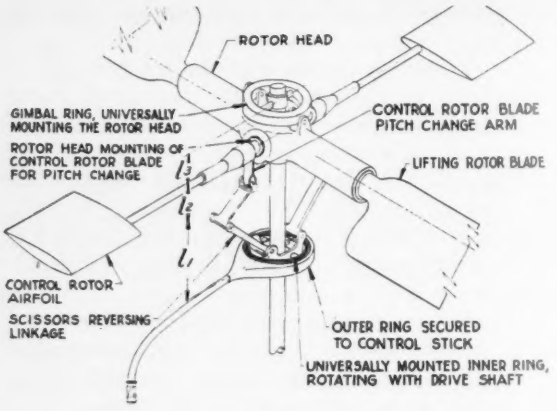

ROTOR HEAD
GIMBAL RING, UNIVERSALLY MOUNTING THE ROTOR HEAD
ROTOR HEAD MOUNTING OF CONTROL ROTOR BLADE FOR PITCH CHANGE
CONTROL ROTOR BLADE PITCH CHANGE ARM
LIFTING ROTOR BLADE
CONTROL ROTOR AIRFOIL
SCISSORS REVERSING LINKAGE
OUTER RING SECURED TO CONTROL STICK
UNIVERSALLY MOUNTED INNER RING, ROTATING WITH DRIVE SHAFT

FIG. 7.

Donnell blade in its first three beamwise and chordwise modes, nonrotating and rotating. In particular, he established the effect of hinge eccentricity.

Joseph Stuart, III, United Helicopters, took as his subject "The Helicopter Control Rotor," described a highly aerodynamic servo for the rotor control, convinced us that an effective and easy control had been achieved with stick shake unlikely, and argued, with equal ability but with less assurance that others would be convinced, that the new control had also indirectly achieved stability. The new control has been applied to a new helicopter model, the Hiller 360, which seen in flight does not depart too much from the conventional tail rotor helicopter of the two-bladed tetering type. This model is powered with a 178-hp. Franklin engine and is designed to carry a pilot and two passengers seated abreast of each other.

The control system is illustrated by the diagram in Fig. 7. The lever, rising vertically out of the fuselage just ahead of the cooling air screen, is part of the collective pitch system. The collective pitch lever pivots about a point on top of the transmission case and through a collar sliding on the drive shaft, and suitable mechanism raises or lowers the collar on the very top of the drive shaft. This collar in turn, by means of pivoted links, changes the pitch of both main blades simultaneously. So far we have good standard practice. It is in the cyclic control that Stanley Hiller, Jr., the designer, has departed boldly from the conventional. The hub into which the blades on either side fasten is universally mounted on two gimbal pins placed somewhat above it. The two lifting blades appear to be of uniform plan and thickness. Attached to the same hub but placed at 90° to the main lifting blades, there are located two servo or control blades of symmetrical profile, mounted at the end of their respective arms and hinged at their respective aerodynamic centers. The cyclic control or azimuth stick is *overhead*, extends upwards through a gland in the roof of the cabin, and can be provided with a suitable yoke at its lower end for dual control. The azimuth stick connects to a universally mounted swash plate (or transfer bearing as United Helicopters prefers to call it), whose inner ring rotates with the drive shaft. From the swash plate two "scissors" extend upward, link up with short arms protruding from the servo-rotor arms, and change the pitch of the control blades in opposite directions. When the pitches are thus charged, an aerodynamic moment is produced, and the rotor head is tilted *until the plane of rotation of the lifting blades is parallel to the plane of the swash plate.* The full tilt action of the rotor head does not develop until the rotor blades have moved through 180° after the first application of a positive change through the control stick.

What is the end result?—a direct control rotor, actuated by an aerodynamic servo. The aerodynamic servo has fine multiplying power, tilts the tip plane and the direction of the thrust line, and the helicopter follows. Because the control airfoils are small, because they are hinged at their aerodynamic centers and have low moments of inertia, the pilot needs to exert but little strength to displace them. He has nothing but a little friction to overcome. Since pilots do not like a completely nonresisting control stick, centering springs are provided which give a control stick grip restoring rate of about 1 lb. per in. The centering springs give the pilot "feel" of the stick's displacement, discourage overcontrolling by beginners, prevent take-off with the lifting rotor tilted, and moreover provide, when adjustable, a simple trimming means. A number of advantages are claimed for the new control: (1) a minimum of links with reduction of cost and maintenance; (2) a very light control; (3) control input multiplication; (4) no stick shake and no need of irreversible elements to prevent stick shake; (5) complete divorcement of the control from the disturbing influences of the main rotor. Anyone familiar with the helicopter will accept these five points as highly desirable and as likely of attainment with this system.

A simple easy shakeproof control is thoroughly worth-while. Flight tests have also given some surprising demonstrations of stability. The author attributes this stability to the use of the new rotor. He starts this argument by pointing out that there are two basic oscillations in the helicopter: (a) a fast motion in which the lifting rotor stays substantially horizontal and oscillates as a torsional pendulum about the aircraft's center of gravity, and (b) a slow motion in which the lifting rotor stays substantially perpendicular to its drive shaft and the aircraft *as a whole* executes a translational oscillation.

For a typical two-passenger helicopter with conventional control configuration, Mr. Stuart's analysis gives results shown in Table 3.

The figures in Table 3 indicate that the fast motion, in which the lifting rotor stays substantially horizontal, is damped out so quickly that it has no importance. They also indicate that the slow motion, in which the rotor stays perpendicular to its drive shaft and the aircraft oscillates as a whole, is unstable. They also show that the period is so slow that the pilot should have no difficulty in subduing the oscillation.

TABLE 3

	Fast Motion		Slow Motion	
	Period, sec.	Multiplication per cycle	Period, sec.	Multiplication per cycle
Rolling	1.99	0.00009	13.3	1.55
Pitching	Aperiodic	Aperiodic	14.7	3.67

TABLE 4

	Maximum Rate of Roll, Rad. per Sec.	Damping Rate at 1 Rad. per Sec.
Airplane	0.713	11.7
Helicopter	1.395	3.25

TABLE 5

	Fast Motion		Slow Motion	
	Period	Multiplying cycle	Period	Multiplying cycle
Rolling	1.091	0.645	41.6	0.66
Pitching	2.11	0.371	40.7	0.696

Then whence comes the helicopter accidents in which the pilot's efforts are in vain and the motion amplifies dangerously? The answer probably lies in another table given by Mr. Stuart for two aircraft of comparable size (see Table 4).

The airplane develops a much lower rate of roll than the helicopter, and its roll is afterwards much better damped. Thus there is real danger that the helicopter pilot may over control and amplify the motion instead of subduing it. As Mr. Stuart puts it: "These two factors, aggravated by the pilot's being forced to use a rough, noncentering control stick, give ample support for the contention that the conventional helicopters' control characteristics encourage overcontrolling."

Mr. Stuart further maintains that he has a cure in the new type of rotor control described in this story, and says: "The trick is to make the control rotor itself very much more sluggish than the main rotor to give increased damping of the slow angular velocities. Adequate control, however, is easily retained by greatly increasing the cyclic pitch input to the control rotor." What happens is shown in Table 5.

The fast motion is still heavily damped, the slow motion has a much longer period than before, and the oscillation with fixed controls is now damped—that is to say, stable.

The paper needs careful study before the stability considerations are accepted, but at least it opens up the whole question of helicopter stability and removes the defeatist attitude that has existed in this field.

Dr. Klemin's summary of the Sixteenth Annual Meeting, covering the meteorology, Structures, Aircraft Design, and Aerodynamics Technical Sessions, will be continued in the April issue.

I.A.S. National Meeting Schedule

Flight Propulsion Meeting—Hotel Carter, Cleveland—March 19

Annual Summer Meeting—Los Angeles—July 15–16

Members or organizations wishing to submit papers for presentation at National Meetings should send outlines or summaries to the Committee at least 3 months prior to the meeting.

All papers submitted will be considered for publication in the *Journal of the Aeronautical Sciences* or the *Aeronautical Engineering Review*.

All correspondence should be addressed to The Meetings Committee, Institute of the Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

"Survival in the Air Age"

Excerpts from the official summary of the Report of the President's Air Policy Commission. The full document may be obtained from the Government Printing Office, Washington, D.C., for 75 cents.

Photo Courtesy of Fortune Magazine

Air Policy Commission at Work: *This picture was posed, of course, for the benefit for Fortune's photographers, but many a session like it took place during the last 4 months of 1947. The Commission's report, "Survival in the Air Age," has been widely read by U.S. citizens and U.S. industry. Left to right: S. Paul Johnston, Executive Director; Arthur D. Whiteside, Member; George P. Baker, Vice-Chairman; Thomas K. Finletter, Chairman; John A. McCone, Member; and Palmer Hoyt, Member.*

SECTION I

AIR POWER AND THE NATIONAL SECURITY

We believe that the United States will be secure in an absolute sense only if the institution of war itself is abolished under a régime of law. World peace and the security of the United States are now the same thing.

Even the most optimistic view of the record of the United Nations does not assure us that United Nations will develop in time the necessary authority to prevent another great war.

Unilateral disarmament by the United States is out of the question.

The United States must have a double-barrelled policy abroad. It must work to achieve world peace through support and development of the United Nations. And at the same time it must prepare to defend itself for the possibility that war may come.

Relative security will be founded only in a policy of arming the United States so strongly (1) that other nations will hesitate to attack us or our vital national interests and (2) that if we are attacked, we will be able to smash the assault at the earliest possible moment.

We need a new strategic concept for the defense of the United States. This concept must be based on air power.

Heretofore we have had one force in being, the Navy. Now we need two, the Air Arm and the Navy. Now we must defend both the water approaches and the air approaches.

For strategic purposes we must divide the future into two parts—the present Phase I during which we may assume that we have a monopoly on atomic weapons, and Phase II, the time when other nations will have atomic weapons in quantity and the equipment to deliver them in a sustained attack on the United States mainland.

It would be an unreasonable risk for our present planning purposes to assume that other nations will not have atomic weapons in quantity by the end of 1952. It would be unwise to assume, in the planning of our defense establishment, that other nations will not have the planes and missiles capable of delivering a sustained attack on the United States mainland by the end of 1952.

On first impression it might seem that a major war during Phase I is unlikely. We must be prepared for war during Phase I. In Phase II we need an even stronger force. An attack during Phase II would be extremely violent. What we must have and can support in Phase II is a reasonably strong defensive establishment to minimize the enemy's blow, but above all a counter-offensive air establishment in being which will be so powerful that if an enemy does attack we will be able to retaliate with the utmost violence and to seize and hold the advanced positions from which we can divert the destruction from our homeland to his.

The Air Force is inadequate even for this Phase I when we are relatively free from the danger of sustained attack on our homeland. The Air Force is hopelessly wanting in respect of the future Phase II period when a serious danger of atomic attack will exist.

The Air Force in being must be increased from its present level to a minimum regular establishment of 70 groups with 6,869 first-line aircraft, an Air National Guard of 27 groups with 3,212 first-line aircraft, and an adequately equipped 34 group Air Reserve. The level of procurement of new aircraft must be high enough to keep this force modern at all times. An adequate reserve, now estimated by the Air Force at 8,100 aircraft, must be created and kept in a proper state of modernization. We must start now on this program and complete it before the end of 1952.

The Navy Air Arm as presently constituted is adequate. The Navy needs, however, additional funds for the procurement of new aircraft to replace the World War II aircraft which are rapidly becoming obsolescent.

Under the Unification Act of 1947, it is the responsibility of the Secretary of Defense, acting under the President, to see to it that the Joint Chiefs of Staff prepare integrated strategic plans for the defense of the country and consolidate the functions of the Services in such a way that the plans can be carried out with a minimum of personnel and equipment and a maximum of effectiveness. It is of the utmost importance that the work of the Joint Chiefs of Staff, under the Secretary of Defense and the President, to establish these requirements, be completed at an early date.

The current budget for the Military Establishment totals 10,098 million dollars. Two thousand eight hundred and fifty million dollars is for the Air Force, 4,037 million dollars for the Navy, and 3,211 million dollars for the Army. Out of the total budget of 10,098 million dollars, 4,050 million dollars is for naval aviation and the Air Force.

The Commission recommends that the increase in the Air Force to 70 groups be started at once and be completed by the end of the year 1952. This will require an increase in the Air Force budget from the present level of 2,850 million dollars to 4,150 million dollars for the calendar year 1948 and 5,450 million dollars for the calendar year 1949.

The Navy must immediately contract to increase its annual procurement of airplanes in order to equip properly the present

fleet with modern planes as World War II reserves are exhausted. The Navy budget should be increased by 192 million dollars in the calendar year 1948 and by a further 310 million dollars in the calendar year 1949.

The foregoing recommendations of the Commission would increase the military budget from its present rate of 10,098 million dollars to 11,590 million dollars for the calendar year 1948 and to 13,200 million dollars for the calendar year 1949.

The Air Transport Command and the Naval Air Transport Service should be consolidated into one military air transport service which would handle all scheduled transport work for the Army, Navy, and Air Force.

The Commission recommends that the National Security Act of 1947 be amended to provide that the President appoint on June of each second year, or more frequently as he sees fit, a Commission of five citizens, subject to confirmation by the Senate, to review the Military Establishment of the country and its adequacy in the light of the then international military and political situation, and to submit a report of their findings and recommendations to the President on the following January 1. This report to the President should be made public.

Section II

THE AIRCRAFT MANUFACTURING INDUSTRY

A strong aircraft industry is an essential element in the Nation's air power.

As the minimum level to which the industry must be held to provide a safe base for expansion in an emergency, we have adopted the general range of requirements of the Air Coordinating Committee in its report of October 22, 1945.

We believe that military purchases of aircraft of 30 to 40 million pounds annually in addition to demands for commercial and private planes would provide a sound basis for expansion in any emergency.

No artificial stimulation to achieve this result is necessary. If the program outlined in section II is carried out the necessary base for expansion of the aircraft industry will exist. The rate of procurement recommended in section I would increase the present military procurement (which is now at the rate of about 21 million pounds annually) by contracts for an additional 13 million pounds in the calendar year 1948, and for 22 million pounds in the calendar year 1949 more than in 1948.

We recommend that the Armed Services plan their aircraft procurement as far in advance as possible and that Congress provide the legislative base for such planning. We recommend the placing of orders for planes for delivery over a 5-year period whenever possible.

We recommend that there be an annual mobilization budget showing the appropriations necessary to put this budget into effect if mobilization is initiated in the then current year; and that the National Security Resources Board set up an Office of War Mobilization to be held ready for activation upon the declaration of a national emergency and mobilization by the President.

Section III

AERONAUTICAL RESEARCH AND DEVELOPMENT

Intensive research and development in aeronautics is essential to the national defense and to the national welfare.

Our fundamental knowledge of aerodynamic phenomena must be extended in all speed ranges, particularly in the supersonic. The provision of additional funds will not of itself solve the problem—the most serious shortage is in personnel.

The Commission believes that rigid enforcement of wartime security measures with respect to advanced aeronautical development is necessary.

We recommend that the possibility of employing atomic energy for the propulsion of aircraft be followed up.

We believe that more coordination of Government work on research on guided missiles should be provided.

Research by the National Advisory Committee for Aeronautics, with respect to personal aircraft, should seek for lower landing speeds, coupled with higher top speeds. The NACA effort in this area should be limited strictly to basic research and not be applied to the development of any commercial article.

Research and development on gas turbines and rocket engines should be pursued diligently, but research and development on piston type engines should not be abandoned.

More research effort must be put into the development of systems for making blind landings with aircraft. This is presently under consideration by the Air Coordinating Committee.

Each aeronautical research agency should be allocated a lump sum annually, the appropriation to be based on its estimated requirements. Legislation should be enacted to authorize research agencies to make contracts to cover a 5-year period.

The wind tunnels projected under the Unitary plan should be constructed with such priority and at such rate as recommended by the Research and Development Board.

We recommend that education in the aeronautical sciences be given a high priority. We recommend that the Congress remove the salary ceiling for top-caliber scientists.

Section IV

CIVIL AVIATION

The air lines are now passing through one of the most serious crises of their history.

The revenue from passengers and cargo, plus a revenue for the carriage of the mail roughly equal to the passenger rate, will not support the operations of many of the companies. If they are to continue in operation and start again up the ladder toward self-sufficiency, the Government will have to increase the mail rates.

The carriage by air of all first-class mail which can be expedited thereby and the inauguration of a parcel post by air should be given serious consideration by Congress when the air lines achieve a satisfactory regulatory status.

We recommend that new types of transport planes be operated regularly on nonpassenger schedules for a specified mileage before passengers are carried. We believe also that CAB economic control over contract carriers would tend to increase safety.

It is especially important to increase the regularity of service. For safety and regularity a basic requirement is a Nation-wide system of air-traffic control, navigation, and landing aids. The Federal Government must accept the financial burden of providing these aids until those who use them are in a financial position to pay their fair share of the cost. Agreement must be reached as soon as possible by the interested private groups and responsible Government agencies on a common system of landing aids for immediate installation which will adequately serve both civilian and military needs. Government expenditure for electronic aids to air-traffic control, navigation, and landing will do more than anything else to advance the air lines toward self-sufficiency

We recommend that the Civil Aeronautics Board defer for a short time decisions in new route certification cases.

There is need for a comprehensive survey of the present situation. If the CAB does not develop a clear-cut plan for an over-all domestic transport pattern, the Congress should give serious thought to giving the over-all planning function of route development to the Secretary of Civil Aviation recommended in section V.

We recommend that the Civil Aeronautics Board prevent the control by surface carriers of the United States air trans-

(*Continued on page 92*)

Designing Secondary Power Sources and Mechanisms for Airplanes

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SUMMARY

The various functions for which secondary power systems are necessary in aircraft are mentioned, and their importance in the overall airplane design is discussed. A typical design is carried to completion, in which the various problems and alternatives facing the designer are discussed. A method of computing the mechanical efficiency of push-rod and bellcrank mechanisms is presented, with an example. The basic factors underlying the selection of a secondary power system are discussed with particular reference to the Banshee. It is concluded that selection of the combination representing the "best" type cannot be predicted in advance on an airplane differing radically from those in operation. A method of evaluation is presented as an aid in the selection of the optimum system.

A derivation of the "friction circle" formulas, necessary to the evaluation of the mechanical efficiency of push-rod mechanisms, is given in Appendix I.

NOMENCLATURE

The following is a complete list of symbols used in the discussion and Appendix.

C_n = normal force coefficient
d = distance, in.
d = diameter of friction circle
e = eccentricity, in.
E = mechanical efficiency, ratio of output to input
f = frictional force, a shearing force with respect to the bearing surface, lbs.
F = force, lbs.
N = normal force, lbs.
HP = horsepower
MA = mechanical advantage
P = power, average over an operating cycle, ft.lbs. per sec.
r = radius of friction circle, in.
R = radius, in.
q = dynamic pressure of air stream, lbs. per sq.ft.
S = area of aerodynamic surface, sq.ft.
T = torque, in.lbs.
t = time during a cycle of operation
t = thickness, in.
U = energy, average over a cycle of operation, in.lbs.
V = airplane speed, m.p.h.
α = angle traversed in a cycle of operation, rad.
δ = deflection, in.
θ = motor torque shaft travel, revolutions
μ = static coefficient of friction
Σ = summation

Subscripts

r = required
a = available

* Chief Structural Engineer.

FUNCTIONS FOR WHICH SECONDARY POWER IS REQUIRED

EVERY AIRPLANE CONTAINS several power plants: the primary one, which drives the plane through the air, and several secondary ones, which are provided for the accomplishment of some of these operations:

(a) Landing-gear extension and retraction.
(b) Landing-gear emergency systems.
(c) Flap, spoiler, tab, or speed brake operation.
(d) Windshield defrosting and cabin air conditioning.
(e) Wing folding.
(f) Arresting hook extension.
(g) Door operation (landing gear, bomb bay).
(h) Power boost for control surfaces.
(i) Power-plant air regulation.
(j) Boundary-layer control.
(k) Canopy operation.
(l) Gun charging and turret operation.

Primary power plants are marvels of efficiency, while the efficiency of the secondary systems is considerably lower. "Efficiency" is here used in the sense most important to the aeronautical engineer—final power output per pound of installed weight. The discrepancy between primary and secondary power-plant efficiencies is not surprising, since an airplane is built around a specific power plant, and the secondary systems are coerced into whatever nooks and crannies are left over after a minimum of the space available has been alloted to structure.

IMPORTANCE OF SECONDARY SYSTEMS IN OVERALL DESIGN

The manner in which these secondary power sources and their mechanisms are designed is rather important to the finished airplane. The total weight tied up in the performance of the required operating devices must be held to a minimum, but the finished design must operate with complete reliability. Aircraft having reached a stage of aerodynamic development such that the flight performance meets estimated performance fairly closely, the ease and speed with which the above-mentioned secondary items can be operated and maintained becomes an extremely important factor in the tactical usefulness of an airplane.

Let us consider the various power sources from the standpoint of reliability. Those available include:

(a) Hydraulic cylinders.
(b) Electromechanical actuators (a linear actuator in which an electric motor drives through a worm-threaded shaft; these

actuators, equipped with ball bearings, have a mechanical efficiency of about 85 per cent).

(c) Pneumatic cylinders.
(d) Hydraulic motors.
(e) Electric motors.
(f) Pneumatic motors.

The first three deliver their power as a force acting along a line; the second three, as torque. Draining power from the primary power plant is not listed, but it should be understood that it is a much more efficient source than any of the above. No particular one of the above sources provides a marked advantage in reliability. An electric motor always operates when current is applied; the same may be said for a pneumatic motor or a hydraulic piston when the pressure is available. The problem of providing air or fluid to a device leads to no greater loss in reliability than that of providing electricity to a device. The mechanism (as distinguished from the power source) which conveys the power from its source to its point of application produces most of the loss of reliability in such installations.

The total weight tied up in the secondary power provisions amounts to about 6 per cent of the weight empty on the XF2D-1 Banshee, a typical Navy fighter. In designing the various components of such a system, the engineer is faced with the problem of transferring power around corners and through hinge points, changing from one type of motion to another, all in severely restricted spaces; it is understandable that the systems have low power to weight efficiencies. Table 1 compares the efficiency of the primary power plant with that of the secondary systems on the XF2D-1.

From these data it is seen that the attainment of as good efficiencies on the secondary sources as have been attained on the primary power plant will result in a weightsaving of about 500 lbs. Of course, most of this saving is unattainable, but it shows that considerable improvement is possible.

General Design Considerations

In achieving the low weight of mechanism attained in present designs, aircraft designers are forced to depart from practice accepted in other fields of engineering. For instance, bearing pressures in plain steel-on-steel bearings are allowed to run up to 40 to 50 per cent of the yield bearing strength of the material. One commonly used reference source indicates that such bearings will jam at a few thousand pounds per square inch; were this true, a majority of aircraft mechanisms would fail to function. Ball bearings are selected for which the manufacturer's static non-Brinell load is no higher than the maximum operating load, but the manufacturer's operating load rating for the bearing is generally 25 to 50 per cent of the static non-Brinell rating. Gear manufacturers recommend that their product be subjected to operating stresses around 10 or 20 per cent of the yield strength of the gear material; aircraft mechanisms are consistently designed for two to five times these values.

An aircraft design consideration not present in most engineering problems is the difficulty involved in providing mechanisms that are reliable when mounted in flexible structure. A mechanism extending over any appreciable part of the span of a wing, for instance, may have to be designed so that it will operate when the airplane is subjected to 8g, during which the displacement of the wing tip with respect to a horizontal reference plane may amount to $^1/_2$ in. per ft. of span. As well as misalignments resulting from overall structural deformation, local supporting points must be light and therefore flexible in order to reduce the weight penalty. Also, the fact that the airplane is composed largely of faired surfaces leads to large tolerances in the location of supporting points; ± 0.05 in. is as close as can be depended upon without special locating fixtures.

It is surprising that reliable designs can be obtained on such a basis; the reason that they are reliable is that the manufacturer's ratings are set up for continuous duty under various adverse conditions; in aircraft, the high load demands are infrequent and of short duration; maintenance is good, leading to favorable operating conditions; and frequent replacement is expected. Even so, the attainment of reliable mechanisms under these design conditions is not an easy task. Only positive mechanisms may be used; by positive is meant devices that, when actuated, either operate or break something. This often rules out the use of spring-return devices, cams, and slotted arms and limits the use of cables to mechanisms in which a return cable can be provided. The push-rod and bellcrank type of mechanism enjoys the greatest favor in aircraft, since it is positive, can be designed to work satisfactorily on the flexible base which aircraft structure provides, is adaptable to severe space limitations, and is in general lighter than alternative types, such as gear trains.

Power Determination in a Typical Design

A certain amount of basic data is necessary before the design of any power source and mechanism can be attacked intelligently. First, definitely rated power sources and transmitting devices must be available. This requirement is satisfied, for instance, in the case of a hydraulic cylinder actuated by a pump operating at a definite pressure and flow. Manufacturer's ratings are generally reliable for motors, actuators, and reduction units. The author has had only one unfortunate experience in this respect: a worm-and-gear unit claimed by the manufacturer to have a mechanical efficiency of 50 per cent turned out around 25 to 30 per cent when finally tested. The efficiency as measured on test, incidentally, checked closely with the values given in a text on machine design. Manufacturer's "nominal" ratings are generally well below the actual capacity of the unit; however, firms dealing with aircraft units have adopted the practice of also stating the maximum ratings in order to make their product competitive on a power-weight efficiency basis.

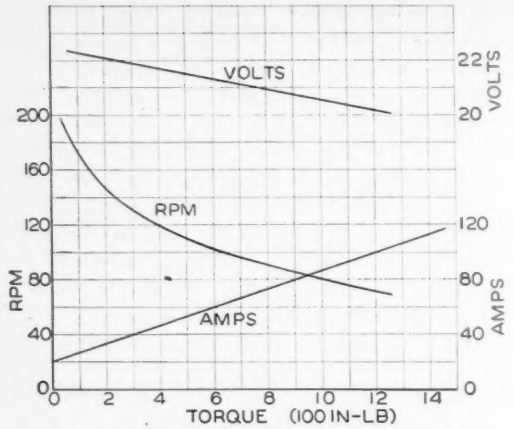

FIG. 1. Rating curve, Motor A.

Next, power requirements must be definitely assessed. This leads to rather broad assumptions in designing many of the aircraft components for which power operation is required. Taking flap actuation as an example, the process is as follows:

(a) The maximum airplane speed at which flaps must be extended is selected.

(b) The pressure distributions and corresponding flap hinge moments are determined for various flap positions. The problem here is the wealth of data available, none strictly applicable to the problem at hand; however, the magnitudes and distributions of load in any problem can be determined within a fairly small range. The absolute validity of this statement is an important one for the designer to grasp, since his quest for power requirements often runs aground on a load specialist's quandary. When the specialist (usually an aerodynamicist) is asked, "What is the value of such-and-such?" he replies, "Very good question...going to have to change the span...data subject to interpretation...tunnel chokes up...report missing from file...next month we'll get...so I can't give you an answer now." However, if the question is put, "What are the maximum possible and minimum possible values?" it will be found that both answers wind up by dictating the same power source in some cases and allowing little leeway in the selection in the rest.

(c) Total energy required for a cycle of operation is determined by

$$U_r = T\alpha \text{ or } Fd \qquad (1)$$

where

T = average hinge moment, in.lbs.
F = operating force
d = total distance operating force moves from up position to down position

or more precisely

$$U_r = \int_{\alpha_{up}}^{\alpha_{down}} T d\alpha \text{ or } \int_{d_{up}}^{d_{down}} F dd \qquad (2)$$

(d) The power required is determined from the energy and a time requirement:

$$P_r = U_r/t \text{ and } HP_r = U_r/550t$$

(e) Power required is compared with power available from any given power source and mechanism to determine its adequacy. Peak load points must also be investigated to ensure that the system has sufficient maximum power.

Example 1: Flap Operation

Taking an airplane having two split flaps, each 10 ft. by 18 in., hinged at the leading edge of flap, the previously outlined computations are:

(a) V = maximum speed at which flap operation is required = 200 m.p.h.

(b) Given: total flap travel = 60°; C_n = 1.2 (flap down); CP = center of pressure of normal force = 40 per cent chord. Then

$$N = C_n qS = 1.2\ (200^2/391)\ 30 = 3{,}680 \text{ lbs.}$$
$$T_{max.} = N(\text{C.P.}) = 3{,}680(0.4)\ 18 = 26{,}500 \text{ in.lbs.}$$

(c) Considering the operating cycle from up position to down position and assuming zero hinge moment at flap up and linear variation with angle to the down position:

$$U_r = T\alpha = 26{,}500(60/57.3)/2 = 13{,}900 \text{ in.lbs.}$$

(d) Assuming 10 sec. is allowed for flap extension:

$$P_r = U_r/t = 13{,}900/10 = 1{,}390 \text{ in.lbs. per sec.}$$
$$= .116 \text{ ft.lbs. per sec.}$$
$$HP_r = U_r/550t = 0.21 \text{ hp.}$$

Motor A (Fig. 1) has a nominal rating (the actual horsepower at two-thirds maximum torque—i.e., 800 in.lbs.) of:

$$HP = P/550 = 2\pi Tn/(60 \times 550) =$$
$$2\pi \times 800 \times 90\ (60 \times 550 \times 12) = 1.14$$

Since 0.21 hp. is required and 1.14 hp. is available, Motor A appears, at this point in the investigation, entirely too heavy. However, the entire 1.14 hp. is not available at the point of flap actuation, since whatever mechanism is employed to transmit the power cannot have 100 per cent mechanical efficiency. Let us assume the motor operates the flaps through a torque tube driving a jack-screw that operates against an arm cantilevered from the flap. The torque tube will be assumed 100 per cent efficient, which will be nearly the case if proper provisions for misalignment are made by means of flexible supports and universal joints at strategic points. The jack-screw has the following characteristics:

Lead = 0.125 in. = L
Pitch radius = 0.28125 in. = R_p
Thread type: Acme (square)

The mechanical efficiency of this jack-screw under load can be computed from energy input per energy

output. Unit axial load requires an extending torque of:

$$T = P\frac{(L + 2\pi\mu R_p)R_p}{2\pi R_p - \mu L}$$

$$= 0.0774 \text{ in.lbs. (see reference 1)}$$

and unit extending torque produces an axial load of $1/0.0774 = 12.9$ lbs.

Since a unit of energy (1 in.lb. acting through 1 rad.) produces $0.125/2\pi = 0.0199$ in. of extension, the corresponding energy output is $12.9\ (0.0199) = 0.256$ in.lb., and the mechanical efficiency is 25.6 per cent. Therefore, only $1.14\ (0.256) = 0.292$ hp. is available for flap actuation. Comparing this with the 0.21 hp. required, Motor A seems adequate, having a 39 per cent margin of safety based on average operating conditions.

This particular jack-screw can be made to operate the flaps 60° in about 10 sec. by selecting a 3-in. (average during travel) flap arm, which corresponds to a jack extension of approximately 3 in. during the cycle. The operational adequacy may be checked as follows: At the average flap hinge moment of 13,250 in.lbs., the actuator load is $13,250/3 = 4,420$ lbs., corresponding to a motor torque of $4,420/12.9 = 343$ in. lbs. Referring to the motor rating curve, Fig. 1, this torque corresponds to 125 r.p.m. The 3-in. jack travel requires $3/0.125 = 24$ turns of the motor, which takes $24(60)/125 = 11.5$ sec. This is a rather rough approximation, since the parameters involved are not linear with respect to either jack travel or flap angular travel; a closer approximation may be made by breaking the cycle into increments and assuming average values for each of the variables as constant across the increment; an exact solution may be made by performing the integration (graphically, since an analytical expression for r.p.m. $= f(T)$ is not available).

It is necessary to check the peak load condition, since the average over the cycle has been the basis for previous computation. (The above-mentioned integration furnishes a check at the peak load.) At full extended, the following conditions obtain:

$$T = 26,500 \text{ in.lbs.}$$
$$P = 26,500/3 = 8,850 \text{ lbs.}$$
$$\text{Motor T} = 8,850/12.9 = 686 \text{ in.lbs.}$$

Since the motor can exert 1,200 in.lbs. maximum (see Fig. 1), Motor A is entirely satisfactory for operation of the flaps. If a closer check of the time for operation indicates that the 10 sec. time requirement is not being met, the 3-in. arm can be reduced slightly, which will result in faster operation and a higher peak load. Faster operation can also be obtained by increasing the lead of the jack-screw, but this reduces the jack-screw efficiency slightly. Another item to consider is the irreversibility of the jack-screw. When the helix angle exceeds the friction angle (i.e., arc tan μ) the screw is reversible; a helix angle of 7° or less (corresponding to $\mu = 0.128$ or more) is recommended for irreversibility.

It should be noted that the computations are not affected by the number of jack-screws used to operate the flaps.

The power requirements may not be so easily determinable, as in the case of a door with its hinge line parallel to the air stream. In this case a reasonable estimate may be made by assuming a maximum design speed and a maximum gust speed or angle of yaw and using flat plate aerodynamic coefficients for a determination of the force applied to the door.

Mechanical efficiencies of various types of machine elements are determinable within 5 per cent or so and may be found in various texts.[2]

Computation of Mechanical Efficiency of Bellcrank and Push-Rod Mechanisms

As previously mentioned, rod and crank devices make up the majority of aircraft mechanisms. Values of mechanical efficiency for such mechanisms are not given in texts, since, under ideal conditions, nearly 100 per cent efficiency may be realized; but various factors may reduce the efficiency to zero. The computation of efficiency involves the determination of the ratio of force input to force output, both with and without friction, at various positions of the linkage. The efficiency differs from 100 per cent only because of friction in the joints. The factors determining the amount of friction in a joint are (a) the type of bearing, (b) the quality of lubrication, and (c) the forces imposed on the joint by the type of joint and the eccentricity of the supporting structure. A consideration of these factors in detail follows.

(a) *Type of joint:* For properly lubricated ball bearings permitting a few degrees of misalignment, the friction is zero for all practical purposes, regardless of the nature of item (c) above. Ball bearings are accepted as the most trouble-free type of joint, but in many instances space and weight limitations dictate the use of plain bearings.

(b) *Quality of lubrication:* In plain bearings a coefficient of friction of $\mu = 0.20$ is recommended as conservative for design. Since the exact value of μ to be used has a great influence in determining efficiency, close consideration should be given to its determination.

Steel-on-steel plain bearing is often used where the mechanism must transmit large forces, but the amount of rotation is small (one or two rotations per operation, as in a landing-gear trunnion). The static coefficient of friction for dry steel-on-steel is $\mu = 0.58$, many presumably reliable sources to the contrary notwithstanding. The lack of agreement in quoted values lies in the different cleansing agents used by different investigators. An extremely thin film will affect results, as is proved by a test[3] in which the investigator, having measured the above value for dry steel-on-steel, rubbed his clean dry hand across the bearing surface and then measured a value of $\mu = 0.15$, corresponding to animal

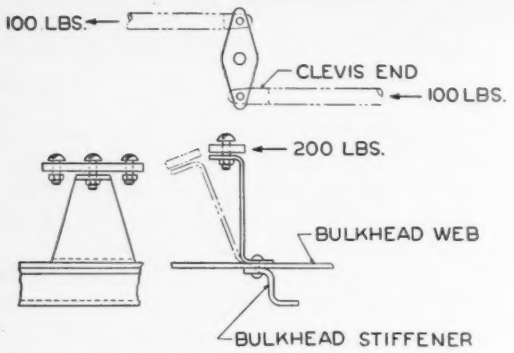

FIG. 2. Flexible bellcrank support.

lubricants. For boundary conditions of lubrication (i.e., an extremely thin film of oil such as exists at high bearing pressures in unsealed bearings), the following coefficients apply:

Mineral oil: $\mu = 0.15$ to 0.19
Animal or vegetable oil: $\mu = 0.12$ to 0.15

These coefficients were determined at bearing pressures around 75,000 lbs. per sq.in. With lower bearing pressures where a thicker oil film can be maintained, much lower values of μ are obtainable, but for the joints under consideration the quoted values hold. For plain bearings other than steel-on-steel, values of μ are negligibly smaller; hence, the recommended value of $\mu = 0.20$ is a conservative one.

(c) *Forces tending to bind the bearing:* It is well known that plain bearings, when used in such a way that a "cocking" tendency is present, may bind. The binding is a result of prying forces between the two rotating surfaces and may be eliminated by the use of the proper type of joint and supporting structure.

To illustrate the effect of mounting point eccentricity on joint friction, let us consider a mechanism consisting of alternate push-rods and bellcranks. A support for one of the bellcranks is shown in Fig. 2. This is deliberately designed to be a structural atrocity; the single shear method of mounting, cantilevering the load to the bulkhead by means of flat sheet bracket, and attaching the bracket to a bulkhead stiffener so as to carry the load by means of torsion in an open section are all poor design. If all these joints have clamp-up bushings (the most generally used type of plain bearing), it is seen that, under load, prying action occurs between the bearing surfaces at each joint, leading to binding of the bellcrank. The use of self-aligning bearings at either of the two end joints or the center joint could conceivably allow operation with such an elastic support; however, the most efficient (and only reliable) design will incorporate a rigid, double shear mounting point for the bellcrank and ball bearings at the center joint. (Ball bearings, which permit a few degrees of misalignment, are still required, since even with optimum rigidity in the supporting bracket, misalignments due to shop assembly and deformation of the structure under limit loads must be considered.)

The effect of friction in joints using plain bearings can best be evaluated by use of the "friction circle" method. Formulas for computing friction circle diameters are given in Appendix I. The friction circle diameter for a double shear connection, as shown in Fig. 3, is $d = \mu D$, where D is the diameter of the pin at that joint. As illustrated in Fig. 4, the torque set up by joint friction is represented by displacing the push-rod force away from the centerline of the rod. The bellcrank shown has a theoretical mechanical advantage of unity; computing the ratio of driving force to driven force with the force vectors displaced tangent to the friction circles at each joint, the mechanical advantage is 1.9/2.1 or 90.5 per cent. The mechanical efficiency of the joint is:

$$E = MA_f/MA_0 = 0.905/1.000 = 90.5 \text{ per cent}$$

where

MA_f = mechanical advantage, friction considered
MA_0 = mechanical advantage, neglecting friction

This simple example illustrates the principle involved. Its application to a practical problem is outlined, using a semigraphical method, which the author has found more convenient than purely analytical methods.

(1) On a full-size or double-size layout of the mechanism (including true views of all bellcranks), the load against which the mechanism must operate at that particular position is drawn as a vector. In the flap example, this would be the load in the screw-

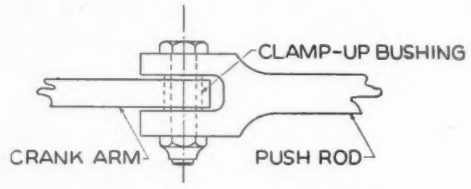

FIG. 3. Double shear connection for minimum friction.

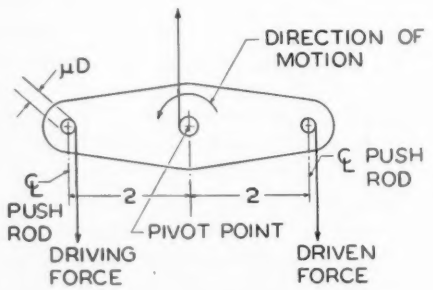

FIG. 4. Effect of friction on pivot-point reactions.

jack which produces the 13,250-in.lb. hinge moment. A complete load analysis is run, determining the load in each link by means of the principle $\Sigma M = 0$ at each pivot point. Friction is neglected. Scaled moment arms are sufficiently accurate.

(2) The theoretical mechanical advantage of the system is determined by the ratio of the loads at the two ends of the mechanism.

(3) Friction circles are drawn at each joint with the following diameters:

Type of Joint	Friction Circle Diameter
Ball bearings or roller bearings in rigid mounting brackets	0
Plain bearings using a double shear joint, or a single shear joint in which rotation occurs on the bearing surface not subjected to couple loads	μD
Single shear joint in which rotation occurs on the bearing surface subjected to couple forces	$\mu D\left(\frac{3e}{t}+1\right)$*

(4) Lines of force are drawn tangent to the friction circles instead of through the joint centers. The proper tangent is selected by considering that the friction always operates to reduce the mechanical advantage, going from driving to driven element. This is an insufficient criterion for selection of the proper tangent in some cases; the incipient motion of the joint, together with the type of loading (tension or compression), dictates the direction of frictional torque and the correct tangent.

(5) Using the displaced lines of force, the mechanical advantage of the system is recomputed.

(6) The mechanical efficiency of the mechanism for this particular position is:

$$E = MA_f/MA_0$$

*See Fig. 8a for an illustration of e.

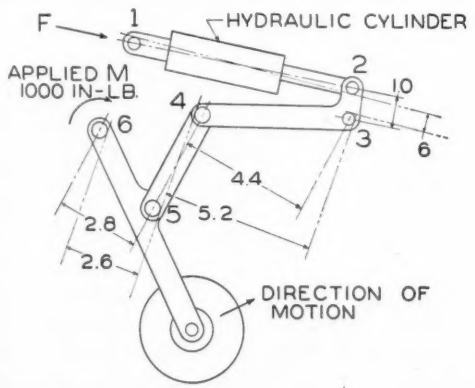

FIG. 5. Typical nose gear mechanism.

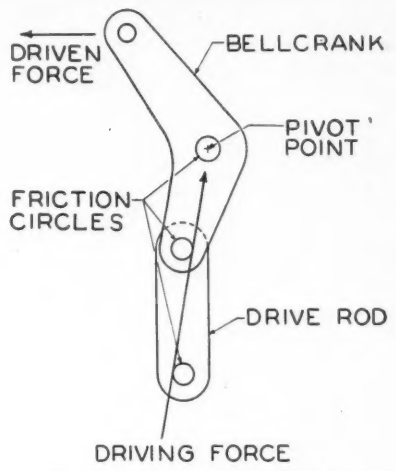

FIG. 6. Zero efficiency mechanism.

(7) In general, the computation must be repeated at several different positions of the mechanism to determine the mechanical efficiency at all operating positions.

(8) From the loads thus determined, a curve of actuator load vs. actuator travel is drawn. Integration of this curve yields energy output required. On the basis of a specified time, the average power requirement may be determined as before—in this case, the area under the curve of minutes per inch of actuator extension vs. inches of extension yields the total time.

Using the nose-gear mechanism shown in Fig. 5 and considering the cycle during which the gear goes from extended position to retracted position, the computation is as follows (operation numbers follow those above; items (1) and (3) are completed in Fig. 5):

(1) The load against which the gear must retract is resolved into a 1,000 in.lb. moment about joint 6, Fig. 5.

(2) Taking successive moments about the pivot points,

$$F = (1{,}000/2.8)\,(4.4/1.0) = 1{,}570 \text{ lbs.}$$
$$MA = 0.637 \text{ in.lb. per lb., neglecting friction}$$

In general, mechanical advantage is expressed as a ratio, pounds per pound; in this case, the effect of joint 6 on the efficiency would have been neglected had the mechanical advantage been computed as the ratio of actuator load to load in link 4–5.

(4) Selection of the proper displacement for the line of force in link 4–5 is made as follows: At joint 4, a tensile force in link 4–5 must act at the left-hand tangent of the friction circle in order to produce a counterclockwise torque on the crank 4–3–2 about the joint center. This torque must be counterclockwise, since the incipient motion of link 4–5 is counterclockwise with respect to joint 3 for the cycle under consideration. Proper selection of friction circle tangents for all the other force vectors can be made on the basis of reduction in mechanical advantage going from 1 to 6.

TABLE 1
XF2D-1 Secondary Power System Efficiencies

Item	Actuator Weight, Per Unit	Mechanism Weight, Per Unit (Not Including Item Operated)	Weight of Structural Provisions for Actuator and Mechanism Per Unit (Not Including Item Operated (Estimated)	Installed Weight		H.P. at Peak Operating Load, Per Unit	Index of Efficiency, H.P. Per Pound of Actuator	Index of Efficiency, H.P. Per Pound Installed
				Per Unit	Per Airplane			
Primary Power Source: Westinghouse 24 B Unit	1200	0	20	1220	2440	3000 (at V = 375 mph)	2.50	2.46
Secondary Power Sources:								
1 Main Gear Linear Actuator	19	0	0	19	38	.76	.040	.040
2 Nose Gear and Door Linear Actuator	25	3	5	33	33	.62	.025	.019
3 Main Gear Door Linear Actuator	9	9	3	21	42	.27	.030	.013
4 Wing Fold Linear Actuator	24	4	20	48	96	.58	.024	.012
5 Wing Pin Pull Linear Actuator	8	5	1	14	28	.14	.018	.010
6 Engine Air Valve Linear Actuator	9	1	1	11	22	.12	.013	.011
7 Canopy Operating Motor	7	20	5	32	32	.30	.043	.009
8 Gun Charging Motor-Compressor	11	6	1	18	18	---	----	----
9 Flap Motor	24	45	10	79	79	1.23	.054	.016
10 Speed Brake Motor	10	19	5	34	68	.13	.013	.004
11 Rudder, Elevator and Aileron Tab Mot	7	8	3	18	30	---	----	----
12 Nose Gear Emergency Motor	2	0	0	2	2	.03	.013	.013
13 Arresting Hook Actuator	4	21	5	30	30	.04	.009	.001
Total Weight of Secondary System					518			

(5) Considering friction:

$$F = (1{,}000/2.6)\ (5.2/0.6) = 3{,}330 \text{ lbs.}$$
$$MA = 1{,}000/3{,}330 = 0.300 \text{ in.lb. per lb.}$$

(6) $E = MA_f/MA_0 = 0.300/0.637 = 47$ per cent.

(7) A lower efficiency will be found at the extreme positions of the gear, since arm 2–3 becomes shorter. In general, the lowest efficiencies are found at positions of the mechanism where actuator loads are highest.

(8) Having determined efficiencies at several positions, the operational adequacy of the hydraulic cylinder may be determined in the same manner as previously used in flap example.

The layout on which the mechanical efficiency is determined is useful in investigating other characteristics of the system. It will be noted that close-coupled cranks lead to lower efficiencies than long ones; this effect can be seen in the nose-gear problem, where the crank arm 2–3 contributes most of the loss in efficiency. In a case where a displaced line of force passes inside the pivot-point friction circle, as shown in Fig. 6, the efficiency has gone to zero, and an infinite force cannot operate the mechanism.

Another item that can be investigated on the layout is the effect of local or general structural deflections. Using the loads at pivot points, the amount and direction of their movement may be computed by conventional methods of stress analysis. The effect on efficiency is determined from a recomputation using the revised locations. The effect of shop tolerances and overall fuselage bending may be evaluated in the same way; the latter effect is in this case negligible. Joints that break off of dead center under load should be examined carefully with respect to the above three effects, since any of them can render the system inoperative.

Joints that are supposed to stay on dead center under load should also be investigated in the above manner for the effects of local and general structural deflections and shop tolerances. The author recently had occasion

TABLE 2
Weight Penalty to Airplane Model—Based on an Electrical, Hydraulic, or Pneumatic System

	Item	Secondary Power Source	Mechanism	Structural Provisions	Central Power Source	Power Transmission	Total Weight Penalty
1	Main Gear Retraction						
2	Nose Gear Retraction						
3	Main Gear Door Operation						
4	Nose Gear Door Operation						
5	Main Gear Emergency Operation						
6	Nose Gear Emergency Operation						
7	Flap Operation						
8	Tab Operation						
9	Speed Brake Operation						
10	Cabin Air Conditioning						
11	Cabin Pressurizing						
12	Power Control Surface Operation						
13	Wing Folding						
14	Arresting Hook Extension						
15	Bomb Door Operation						
16	Power Plant Air Regulation						
17	Boundary Layer Control						
18	Canopy Operation						
19	Canopy Jettisoning						
20	Drop Tank Jettisoning						
21	Gun Charging						
22	Turret Operation						
	Total Weight Penalty						
		includes: Electrical actuators and motors Hydraulic cylinders and motors Pneumatic cylinders and motors	includes: Push-pull mechanisms, cables, pulleys, gear trains, torque tubes, dead center and locking mechanisms between secondary power source and actuated items	includes: Mounting brackets, stops, cut-out reinforcements, modifications to basic structure or actuated items	includes: Provisions for using primary power plant, central motor, battery, accumulators	includes: Switches, wiring, inverters, lines, fluid, plumbing; selection, by-pass, check, and pressure reduction valves	

to investigate an item of this type—an arresting gear mechanism in which the overcenter setting was intended to keep the mechanism in place under load. The structural deflections and geometry of the system were such that the centers were reversed at limit load, and a large increase in overcenter setting was necessary to have sufficient overcenter setting at ultimate load.

An energy solution to the deflection problem sometimes works out more elegantly than a part-by-part deflection computation. This involves a summation of the strain energy stored in the structure by the application of limit load. Equating this energy to $F(\delta/2)$ leads to solution of the deflection at the desired point. The detail method of attack is plain to the stress analyst who is familiar with the energy method of determining truss deflections. The energy solution is no more accurate than a part-by-part deflection computation, since each requires an assumption of load mode in each part.

SELECTION OF A TYPE OF POWER SYSTEM

Table 1 presents indices of efficiency for "all up" weight of various operating devices for the XF2D-1 airplane. If it were now desired to determine the comparable weight of an hydraulic or pneumatic system, it can readily be seen that the information given in Table 1 is not the whole story. To get the electrical system on a comparable basis, the weight of battery, wiring, switches, and other items would have to be added. This weight would then compare directly with an hydraulic design in which the cylinders, mechanisms, plumbing, power source, and accumulators were included. The fact that the power-weight efficiencies

vary widely from one installation to another is a reflection of the large variation in the demands of detail design. The conclusion is inescapable that the only way to arrive at an optimum overall system for any particular airplane is by an investigation of the detail design of each installation. The results of such an investigation may be presented by the tabulation of Table 2, making a separate table for each of the types of system (or combination) under consideration. In evaluating an airplane on the basis of Table 2, the designer is limited by several considerations. Available power sources must be used, which necessitates in some cases the selection of units considerably overpowered. An airplane requiring many operating devices will utilize a central power plant more effectively than one having only a few. Weight and complexity of mechanisms vary greatly from one airplane to the next because of varying space limitations. The question of sequence has a great effect on weight of mechanism; where hydraulic or electrical sequence switches are considered unreliable, considerably more mechanism is required to accomplish a direct mechanical hook-up.

Finally, the power-weight efficiency of mechanisms being subject to the vagaries of the detail design of joints and supporting structure and the ingenuity of the designer, it is an impossible task to evaluate accurately an experimental airplane previous to its design in the light of Table 2. Only for an airplane for which the detail design of each installation has been worked out on the basis of its peculiar power requirements, considering the mechanical efficiencies enforced by its particular space and motion limitations, is it possible to evaluate the overall operational picture in a comprehensive manner.

In conclusion, it should be pointed out that the evaluation of power mechanisms here considered involves the selection on the basis of engineering efficiency only. The factors of cost, availability, servicing facilities, and manufacturing techniques often overshadow the pure engineering consideration. Nevertheless, the designer of these operational devices has within his power the means of making or breaking the airplane.

Appendix I

Determination of Friction Circle Diameter

The friction circle diameter for a joint in which no "cocking" action is present is determined as follows: In Fig. 7, assume the force N is applied by a push-rod to the bellcrank arm as point bearing at point A. Since $f = \mu N$, the torque set up about the pin center by rotation of the joint is

$$T = fR = \mu NR$$

The radius of the friction circle, as implied by its use in the previous analysis, must be such as to cause the link force N to set up a torque $T = rN$ about the pin center. Equating the two values of torque,

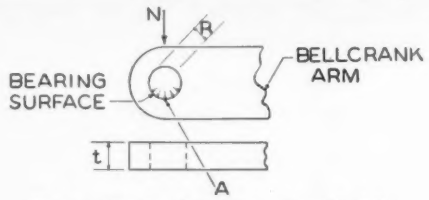

Fig. 7. Bearing force in a concentric joint.

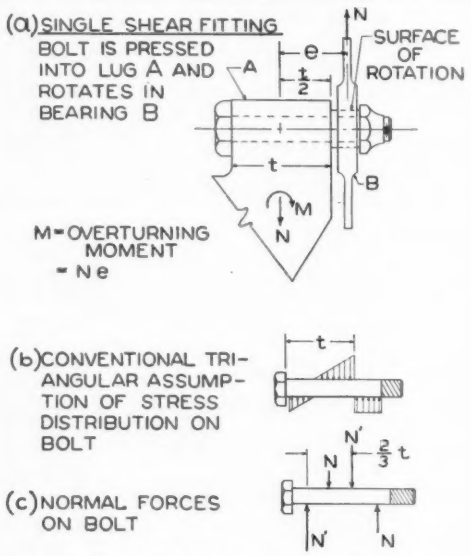

Fig. 8. Bearing forces in a nonconcentric joint.

$$\mu NR = Nr$$
$$r = \mu R$$
$$d = \mu D \tag{3}$$

The assumption of uniform bearing stress over the semicircle leads to the relationship

$$d = (\pi/2)\mu D = 1.57\mu D \tag{4}$$

but since the actual bearing intensity approaches the point loading condition, the use of Eq. (3) is negligibly unconservative.

The derivation of the friction circle diameter emphasizes the necessity of having concentric joints—that is, joints in which no "cocking" tendency is present. The safest way to get this result is by using double shear connections, as shown in Fig. 3. The proper effect can also be obtained in single shear connections as shown in Fig. 8 by having the rotation occur on the bearing surface not subjected to couple forces. However, if the joint of Fig. 8 is arranged in such a way that rotation occurs between the bolt and lug A, the torque created by the friction is determined:

$$N' = 3Ne/2t$$

where N' is one of the two equal couple forces resisting the overturning, as shown in Fig. 8c. The sum of all the normal forces applied to the rotating surface of the bolt is then

$$\Sigma N = 2N' + N$$

The torque set up by bolt rotation is

$$\begin{aligned} T &= R\mu(\Sigma N) = \mu R(2N' + N) \\ &= \mu R[(3Ne/t) + N] \\ &= \mu RN[(3e/t) + 1] \end{aligned}$$

and the corresponding friction circle diameter is determined by

$$\begin{aligned} rN &= \mu RN[(3e/t) + 1] \\ d &= \mu D[(3e/t) + 1] \end{aligned} \qquad (5)$$

As an example, let us take a lug of the type shown in Fig. 8, which is typical of a landing-gear lug, and assume that $t = 2$ in. and the bearing surface B is 0.50 in. wide. Then e is 1.25, and Eq. (5) becomes

$$d = 2.875\mu D$$

In other words, the friction at the joint is almost tripled by having rotation occur in lug A.

Here again, the friction circle diameter depends on the assumption of stress distribution between bolt and lug. Eq. (3) is based on the distribution of Fig. 8b; the limiting cases yield the results

$$d = \mu D[(4e/t) + 1] \qquad (6)$$

or $d = 3.5\mu D$ for the typical lug in the case of square stress distribution, which gives the resultant normal loads shown in Fig. 9a; and

$$d = \mu D[(2e/t) + 1] \qquad (7)$$

or $d = 2.25\mu D$ for the typical lug in the case of the assumed distribution shown in Fig. 9b.

It is seen that Eq. (5), based on the conventional triangular bearing stress distribution, predicts friction effects intermediate between the limiting cases, and its use is recommended for design. The important point is that regardless of the precise stress distribution, joints of the last discussed type, in which rotation occurs on the bearing surface which resists the eccentric moment, lead to high friction during operation and should be avoided altogether.

Another type of joint, which should be used only as a last resort, is such as occurs in a bellcrank of the type

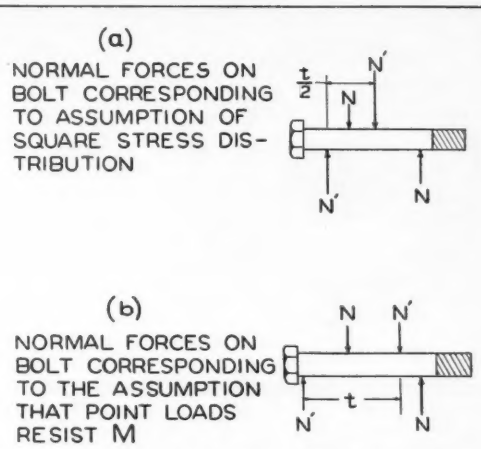

FIG. 9. Limiting cases of bearing stress distribution.

shown in Fig. 2 (plain pivot bearing) but actuated by links having plain bearings also. In this case any deflection of the support point imposes a couple on the pivot bearing. The corresponding friction circle diameter is determined by Eq. (5). In this case, e is the distance from the bearing center to the shear center, or elastic axis, of the mounting bracket. Using the bracket shown in Fig. 2 and assuming $e = 4$ in., $t = 0.4$ in., $D = 0.5$ in., and $\mu = 0.2$. Then substituting in Eq. (5), $d = 3.1$ in.

If the crank arm is less than 3 in., the bellcrank will jam because of friction at the central pivot point alone; friction of the same general magnitude will also occur at the rod attachments, since the overturning couple at the central pivot point is resisted by the push-rods. The undesirability of this type of joint is readily apparent.

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[3] Fogg, A., and Hunwicks, S. A., *The Static Friction of Lubricated Surfaces*, Journal of Institute of Petroleum, Vol. 26, No. 195, pp. 4 and 5, January, 1940.

Changes of Address

Since the Post Office Department does not as a rule forward magazines to forwarding addresses, it is important that the Institute be notified of changes in address 30 days in advance of publishing date to ensure receipt of every issue of the *Journal* and *Review*.

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I.A.S. Briefs

Summaries of current papers received for publication or presentation at I. A. S. meetings

All papers abstracted in this issue were presented at the Sixteenth Annual Meeting of the Institute, January 26–29.

Many of these papers, after being processed by the Editorial Committee in the usual manner, will appear in full in later issues of the *Journal* or *Review*.

Please see page 49 for preprints that are immediately available.

The Testing of Rotors for Fatigue Life

By

Jonathan Winson

Prewitt Aircraft Company

The object of this paper is to describe an experimental method for the fatigue testing of articulated rotor blades. The method consists in the application of harmonic control to a rotor revolving on a stationary whirl stand. The fatigue stresses met in flight are discussed, and it is shown that these stresses can be well approximated by whirl testing under specified control and speed conditions. Equations are derived for the specification of the test parameters, and discussion is given of the theoretical and experimental considerations involved.

Reduction of Vibration

By

Walter Gerstenberger

Sikorsky Aircraft Division, United Aircraft Corporation

Several important factors related to helicopter vibration and its reduction are discussed. Aerodynamic exciting forces are also described. A graphical solution of aerodynamic and dynamic conditions that determine the control of the helicopter in forward flight is presented which enables one to use strip theory and wind-tunnel airfoil data including the stall region. Dynamic exciting forces, induced by Coriolis accelerations, are also discussed. It is shown for a rotor with three blades that this effect is important from a stress standpoint but not so important from a comfort standpoint. A general method for evaluating this effect for a blade with a drag hinge and damper is given.

The effects of the exciting forces on the blades and on the fuselage are discussed as a second step of this problem. Reference is made to the use of generalized coordinates for the evaluation of these effects, and a simplified example of the response of the fuselage is given showing desirable fuselage frequency characteristics.

Proper choice of rotor configuration and proper design of the fuselage from a vibration consideration have resulted in helicopters that are reasonably smooth. In evaluating smoothness, consideration should be given to the fact that, for low-frequency rotor responses, relatively large amplitudes that involve low accelerations are not necessarily uncomfortable. Should further smoothness be desirable, possible reductions may result in added weight to provide the necessary isolation.

Chordwise and Beamwise Bending Frequencies of Rotating Blades

By

Gabriel Horvay

Engineering General Division, General Electric Company

The higher natural frequencies of a nonrotating blade are simply related to the fundamental frequency, and the frequencies of the rotating blade are also readily expressed in terms of the nonrotating frequencies and the speed of revolution. These frequency relations are rather insensitive to variations in the mass and moment of inertia distributions and the plan form of the blade, so that their determination for one particular blade permits an estimate of the various frequencies of other blades of similar design once their fundamental nonrotating frequency is known.

In this paper the frequency relations are determined for the 23-ft. McDonnell blade, in its first three beamwise and chordwise modes, non-rotating and rotating. In particular, the effect of hinge eccentricity is also established.

The Helicopter Control Rotor

By

Joseph Stuart, III

United Helicopters, Inc.

It is shown that a conventional helicopter is difficult to fly because of the excessive rolling and pitching velocities obtainable and the poor natural damping of these velocities. Heavy control stick loads and friction, tendency to stick whirl and vibration, and aircraft instability are also noted as contributing to helicopter piloting difficulties.

To remedy these deficiencies, a safe aerodynamic servo, in the form of a control rotor, has been developed. It is intro-

duced between the pilot's control stick and the cyclic pitch input to the lifting rotor.

The design considerations proportioning the control rotor and its control input and output linkages are described. An analysis of the hovering stability and control of conventional and control-rotor-equipped helicopters is also presented.

A Pneumatic Method for Measuring High Gas Temperatures

By

D. W. Moore

Fairchild Camera and Instrument Corporation

The operation of the pneumatic method for measuring high gas temperatures is based upon the well-known equations for the flow of gas through an orifice. Such equations are usually solved to determine the volume or the mass flow of gas, but this paper shows how they may be utilized to measure accurately and rapidly practically any gas temperature.

The method is particularly applicable to the pressing problem of measuring combustion gas temperatures in turbojet and turboprop power plants where both operating efficiency and safety are dependent upon the operating temperature.

Various practical instruments are discussed, including those designed for ram-jet and rocket application.

Measurement accuracy of better than 2 per cent has been achieved, and instruments are being manufactured to measure temperatures in excess of 5,000° R.

Flight Path Control

By

Paul A. Noxon

Eclipse-Pioneer Division,
Bendix Aviation Corporation

This paper discusses the problem of controlling the flight path of an airplane in accordance with signals generated by I.L.S. landing beam, omnirange systems, and the like. The matter is treated from the standpoint of the autopilot engineer. Several typical solutions to the servomechanical problem involved are analyzed by means of the frequency spectrum method. The effect of various physical limitations is pointed out, together with a discussion of the performance to be expected from a system based on a workable compromise between various elements.

Application of the Performance Operator to Aircraft Automatic Control

By

Robert C. Seamans, Jr., B. G. Bromberg, and L. E. Payne

M.I.T., McDonnell Aircraft Corporation, and Jackson & Moreland

This paper contains a discussion of techniques that provide effective means for analyzing aircraft automatic control systems. These techniques are based on the performance operator, a concept developed by Dr. C. S. Draper and his associates in the Instrumentation Laboratory of the Massachusetts Institute of Technology. At this writing, the performance operator method has already been successfully applied to the complete analysis of complex Naval Fire Control Systems.

Until recently, the fundamental aeronautical design problems largely concerned fluid mechanics, structures, power plants, and static and dynamic stability of the aircraft as associated with a human pilot. The increased emphasis on high-speed, automatically controlled flight has forced the designer out of these well-explored fields into comparatively uncharted realms of air-borne system dynamics. It is felt that the performance operator provides a straightforward procedure for better understanding this necessary physical blending of the sensing and control equipment with the air frame in a manner that will provide satisfactory flight maneuvers.

In this paper, the use of the performance operator is described, and several longitudinal control systems are synthesized. The performance operator of the airplane itself can be determined experimentally from data obtained when oscillating the control surfaces in flight. A simpler method requiring considerably less flight time involves the application of step displacements of the control surfaces. Flight-test data presented in the paper, obtained with the U. S. Army A-26 medium bomber, indicate good correlation between the two methods.

N.A.C.A. Investigation of Gas-Turbine Blade Cooling

By

Herman H. Ellerbrock

Flight Propulsion Research Laboratory, N.A.C.A.

The effect of increasing turbine-inlet temperature on turbopropeller and turbojet engine performance is discussed, and marked improvements are noted. Limitations to the increase in turbine-inlet temperature of present-day engines are brought out, and the need for turbine-blade cooling and the status of this problem at the time the N.A.C.A. started on turbine-blade cooling research are taken up.

The work of the N.A.C.A. on turbine-blade cooling is divided into fundamental and applied research. The former covers analytical studies and experimental investigations, and brief descriptions of results obtained in the studies, comparing the increase in effective gas temperature obtainable with different methods of cooling, static and turbine rig details, and other factors of the investigations, are given. The applied investigations refer to specific water-cooled turbines, the construction and some results of tests being given.

Problems of Gas-Turbine Propeller Combinations

By

Frank W. Davis

Consolidated Vultee Aircraft Corporation

A general description of gas turbines is followed by an explanation of the reasons for the choice of the General Electric TG-100 turboprop and the I-40 turbojet as power plants for the XP-81 escort fighter airplane. Results of flight testing with the I-40 prior to receipt of the TG-100 are discussed. Results of ground testing the TG-100 are followed by a discussion of the problems encountered in taxiing and flight testing.

This discussion relates to problems of control, vibration, hunting, feathering, etc., and covers work done with both Aero products and Hamilton Standard Propellers. A short discussion of TG-100 service life is followed by suggestions for the direction of additional engineering effort to improve turboprop operational characteristics.

The Application of Gas Turbines to Aircraft

By

Arthur N. Tifford

Aviation Gas Turbine Division, Westinghouse Electric Corporation

After a comparison of the basic differences between gas turbines and reciprocating engines as applied to aircraft, a general evaluation of the performance of aircraft power plants is made. The resulting generalization of Brequet's range formula clearly shows the range benefits to be derived by turbo-powered aircraft from cruising at high altitudes, from flying at high indicated cruising speeds, and from the use of small wing aspect ratios.

The essential benefit to be derived from derating turbojet engines so as to obtain lower specific fuel consumptions is shown to be the realization of "high altitude" ranges at low altitudes. Considering the desirability of retaining good take-off, climb, and high-speed characteristics, the use of an adjustable tail area for "derating" purposes is indicated.

A Method for Handling the Performance of a Propeller and Its Match to a Power Plant

By

J. P. Grandfield, E. T. Jansen, and J. L. Cooley

United Aircraft Corporation

A method is proposed for handling the matching of a propeller and a power plant. Beyond its use in design analysis, the method may be used for preliminary performance estimations and for routine propeller efficiency determinations. Essentially, the method is based on the use of logarithmic coordinates and transparent graph paper. The advantages are: (a) an extremely rapid solution to investigations that were previously monotonous and lengthy, (b) the proper evaluation of the accuracy and worth of a series of propeller-power-plant calculations, and (c) a clear picture of the performance and the match of the propeller-power-plant combination.

In order to implement the proposed matching method, available wind-tunnel test data, as well as available correlations, have been subjected to analysis, and a method of handling propeller performance characteristics has been developed. Results of this method are presented in the logarithmic coordinate form, together with the mechanism for setting up similar results for material from any data source. This latter propeller performance presentation is an adequate means for extrapolating tunnel test data to higher stream and tip Mach Numbers than those actually given in the basic tests.

Research Toward Greater Air-Line Passenger Comfort

By

K. R. Jackman

Consolidated Vultee Aircraft Corporation

Postwar air-line travel has shown indications of favoring those airplanes on which the most thoughtful design and testing has been expended in the interest of increased passenger riding comfort. On new airplanes, problems of dependable pressurization, adequate ventilation, heating and refrigeration, reduction of cabin noises and vibration, and provisions for comfortable seating have been met in varying degrees, but there is still much progress to be made.

This paper discusses the research efforts made in the last 2 years to increase passenger comfort by reducing airplane cabin noise through the use of the Convair "Sound-Cabin," complete octave analyses, new materials, etc. The reduction of noise by the exhaust augmentor is noticeable both to cabin passengers and to airport personnel. A second section of the paper discusses the problem of testing aircraft seats and cushions, both on the ground and in the air. Subjective versus objective measurements of a "comfort index" are proposed.

Preliminary Results of Detailed Studies of Thunderstorms

By

Horace R. Byers

U.S. Weather Bureau Thunderstorm Project, and University of Chicago

The program for the micrometeorological study of thunderstorms was reported at the January, 1946, meeting of the Institute of the Aeronautical Sciences. The project has now completed two seasons of operations, one in the vicinity of Orlando, Fla., and the other (1947) at Wilmington, Ohio. Some of the more important results are summarized, and two of the most interesting aspects are left for discussion by Mr. Braham and Mr. Moses in subsequent papers at this meeting.

The Structure and Dynamics of the Thunderstorm

By

Roscoe R. Braham

U.S. Weather Bureau Thunderstorm Project

The individual thunderstorm is found to consist of several cells, each containing in the middle stages of development both an updraft and a downdraft. In the early stages the cell consists of an updraft only, and eventual dissipation results when downdrafts are present throughout the cloud. Both the gusts and the drafts have been measured by airplanes using the technique developed by the National Advisory Committee for Aeronautics. Data concerning the magnitude of these phenomena are given. The importance of horizontal convergence and "entrainment" of air in the cloud and of the thermodynamic and aerodynamic effects of the falling rain is stressed. A new thermodynamic approach to the thunderstorm is suggested.

The Details of Surface Discontinuities Associated with Thunderstorms

By

Harry Moses

U.S. Weather Bureau Thunderstorm Project

The data from the surface micronetwork of the Thunderstorm Project show the details of the spread of cooled air associated with the rainfall and downdraft areas of the thunderstorm. Squall winds and sudden temperature and pressure changes are all associated with the rainfall and vertical motions within and surrounding the thunderstorm. The importance of these events for the self-propagation of the thunderstorm is shown.

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133 A Wing Body Problem in a Supersonic Conical Flow—S. H. Browne, L. Friedman, I. Hodes, Aerophysics Laboratory, North American Aviation, Inc.

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105. An Evaluation of the Importance of Fatigue Phenomena in Aircraft—C. R. Strang, L. R. Jackson, L. F. McBrearty, R. V. Rhode, and R. L. Schleicher (A Round-Table Discussion). 34 pages; no illus. (Mimeographed.) $1.10*

106. Measurement of Ambient Air Temperature in Flight—W. Lavern Howland, Lockheed Aircraft Corporation. 13 pages; 5 illus. (Ozalid.) $0.50*

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Aerodynamics

AERODYNAMIC LOADS

Measurements of Pressure Distribution on a Spitfire Wing in Flight at High Speeds (at Mach Numbers Up to 0.85). W. J. Charnley and W. A. Mair. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2160*, August, 1945. 7 pp., diagrs. 7 references. British Information Services, New York. $0.55.

Sideslip Angles and Vertical-Tail Loads Developed by Period Control Deflections. Harvard Lomax. *U.S., N.A.C.A., Technical Note No. 1504*, January, 1948. 62 pp., figs. 6 references.

Flight Measurements of Aerodynamic Loads on the Horizontal Tail Surface of a Fighter-Type Airplane. John B. Garvin. *U.S., N.A.C.A., Technical Note No. 1483*, November, 1947. 55 pp., figs. 1 reference.

Flight Measurements of Horizontal Tail Loads on a Typical Propeller-Driven Pursuit Airplane During Stalled Pull-Outs at High Speed. Lawrence A. Clousing and William N. Turner. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. A-81)*, April, 1944. 61 pp., illus., fold. charts.

Pressure-Distribution Measurements of a Model of a Davis Wing Section With Fowler Flap Submitted by Consolidated Aircraft Corporation. Ira H. Abbott. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-678)*, January, 1942. 18 pp., figs. 1 reference.

High-Speed Wind-Tunnel Tests of a Twin-Fuselage Pursuit Airplane. Joseph L. Anderson and Victor B. Tkac. *U.S., N.A.C.A., Memorandum Report No. A6D03 (Wartime Report No. A-75)*, April, 1946. 71 pp., illus., fold. charts. 2 references.

Pressure-Distribution Measurements on Various Surfaces of a 0.2375-Scale Model of the Douglas XA-26 Airplane in the 19-Foot Pressure Tunnel. C. Dixon Ashworth. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-553)*, October, 1943. 135 pp., illus.

BOUNDARY LAYER

Design of Suction Slots. A. Fage and R. F. Sargent. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2127*, February, 1944. 31 pp., diagrs. 7 references. British Information Services, New York. $1.75.

Visual observations of flow to determine the optimum entry shape of a two-dimensional slot suitable for boundary-layer suction. The optimum entry shape for a given rate of suction is defined as that for which the velocity of flow into the entry is the lowest possible when it just flows full and the flow separation from the front lip is imminent. The entry flow is not sensitive to the ratio of the radius of curvature of the rear lip and the width of the slot. The optimum value of the ratio of the radius of curvature of the front lip to the width increases with the angle formed between the axis of the slot and the tangent to the surface in the upstream direction. The optimum value of the velocity in an entry throat becomes smaller as the axis-tangent angle increases. A forward-facing slot has, therefore, lower resistance to entry flow than a backward-facing slot. Experiments were performed with slots on the wall of a straight circular pipe to check at higher speeds of laminar flow the conclusions made in the first half of the paper. These experiments made it possible to verify the optimum entry shapes of slots for incompressible turbulent boundary-layer suction and to obtain information on slot entries suitable for turbulent boundary-layer suction at high speeds and in compressible subsonic flow. The optimum throat width for compressible turbulent flow and no choke, expressed as a fraction of the boundary-layer thickness, is smaller than for incompressible flow. The ratio of the choke width to the boundary-layer thickness is equal to the ratio of the rate of mass delivered and the rate of mass-flow in the boundary layer multiplied by the Mach Number of the flow just outside the boundary layer. The choke width is independent of the slot angle, but to have an optimum entry width, a forward-facing slot designed for high-speed flow and a medium rate of delivery may not choke at a higher rate of delivery, while a backward-facing slot is likely to choke.

An Experimental Technique for Boundary Layer Research at High Reynolds Numbers. A. V. Stephens and D. L. Craig. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2187*, August, 1939. 9 pp., illus. 4 references.

The pressure distribution over the upper surface of a special smooth wing on a "Hart" airplane was modified by means of a

duct to represent that over the front part of the wing of a larger and faster airplane. The pressure minimum occurred at a distance of 0.6 of the chord from the leading edge and the local velocity there was 1.6 times the flight speed. Transition took place just in front of the pressure minimum.

CONTROL SURFACES

Wind-Tunnel Tests on High-Lift Devices. H. M. Lyon and J. E. Adamson. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2180*, December, 1939. 16 pp., figs. 9 references. British Information Services, New York. $1.00.

Investigation of the Effect of Change of Section on Rudder Hinge Moment. A. S. Halliday, N. E. Sweeting, and W. C. Skelton. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2184*, August, 1941. 15 pp., diagrs. British Information Services, New York. $1.00.

Aerodynamic Characteristics of Several Modifications of a 0.45-Scale Model of the Vertical Tail of the Curtiss XP-62 Airplane. John G. Lowry, Thomas R. Turner, and Robert B. Liddell. *U.S., N.A.C.A., Memorandum Report No. L6F27 (Wartime Report No. L-736)*, July, 1946. 43 pp., illus. 1 reference.

Flight Measurements of the Effects of a Wing Leading-Edge Slot and Other Modifications on the Stability, Maximum Lift, and High Speed of an Observation Airplane. William N. Turner and Betty Adams. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. A-88)*, January, 1943. 85 pp., illus. 3 references.

Aerodynamic Tests of an NACA 66(215)-116, a = 0.6 Airfoil with a 0.25c Slotted Flap for the Fleetwings XA-39 Airplane. Jones F. Cahill. *U.S., N.A.C.A., Memorandum Report No. L4K21 (Wartime Report No. L-629)*, November, 1944. 37 pp., illus. 1 reference.

FLUID MECHANICS & AERODYNAMIC THEORY

The Hodograph Transformation in Trans-Sonic Flow. I—Symmetric Channels. II—Auxiliary Theorems on the Hypergeometric Functions $\psi_n(\tau)$. III—Flow Round a Body. M. J. Lighthill. **IV—Tables.** D. F. Ferguson and M. J. Lighthill. *Royal Society of London, Proceedings, Series A*, Vol. 191, No. 1026, November 18, 1947, pp. 323–341, 341–351, 352–369, figs., 6 references; Vol. 192, No. 1028, December 23, 1947, pp. 135–142, 4 references.

I. A study of the application of the hodograph transformation to transonic problems by considering the steady plane adiabatic flow of a gas in symmetrical channels in which the velocity rises from zero at infinity on the left to a supersonic value at infinity on the right. In part of the hodograph plane the potential and stream functions are three-valued functions, although in the remainder of the plane they are one-valued. Certain important qualitative results are first established by expansion in the physical plane. The conclusions of this theoretical development are applied to the design of such a channel.

II. Derivation of the equations describing the stream function as a function of n in the complex plane.

III. A general solution to the problem of finding a subsonic flow around a body which reduces, when the Mach Number becomes zero, to a given incompressible flow. Since the solution is valid everywhere, that error is avoided of using series in different parts of the plane which analytically are not continuations of one another. The only functions required are a few auxiliary ones and the stream function and its first derivative for the positive integral m. When circulation is present one solution for the problem was found which appears likely to be the only solution.

IV. A tabulation of the functions described in Part II for values of τ between 0 and $^1/_2$ at intervals of 0.02 and for values $1, 2, 3, \ldots$, 15 of n, taking γ equal to 1.4.

The Similarity Law of Transonic Flow. Theodore Von Kármán. *Journal of Mathematics and Physics*, Vol. 26, No. 3, October, 1947, pp. 182–190.

A simplified form of the differential equation for the velocity potential and a similarity law for compressible flow patterns around similar aerodynamic shapes of different thickness ratios. All flow velocities, including free-stream velocity, differ only slightly from the critical velocity of sound. The differences between the actual velocities and the critical velocities are considered as perturbation velocities. The quadratics and higher terms of the perturbations are retained. One of these quadratic terms is of magnitude comparable to the linear term for two-dimensional flow. The similarity law thus arrived at replaces the corresponding law deducible from the linearized differential equation, that, in the subsonic case, results in the Prandtl-Glauert rule and, in the supersonic case, in Ackeret's rule.

Notes and Tables for Use in the Analysis of Supersonic Flow. *U.S., N.A.C.A., Technical Note No. 1428*, December, 1947. 83 pp., figs. 12 references.

A compilation of formulas for the relationships that exist in fluid flows. The section on fundamental relationships includes the general equations for compressible flow: the perfect gas law, the speed of sound equation, Bernoulli's equation, and isentropic relations. Derivative relationships obtained from these equations are grouped by the parameter that is used as independent variable. The differential equations of motion expressed in rectangular coordinates, cylindrical coordinates, and in linearized form are included in this section not because they are frequently used in wind-tunnel operation but because of their general usefulness. The fundamental relationships are applied in the succeeding sections to derive the formulas for: one-dimensional supersonic nozzle theory and nozzle data; shock waves, normal and oblique; the Prandtl-Meyer expansion; the small-perturbation section theory, the large-deflection section theory, and the small-perturbation sweepback supersonic airfoil theory; and flow about cones and wedges. Three tables give numerical values for physical quantities that are often used in the calculation of problems involving a compressible fluid. The figures are carried out to sufficient places to ensure accuracy to four significant figures in the final result. Table I, Subsonic, presents the isentropic relations for pressure, density, temperature, speed of sound, and area ratios as a function of Mach Number. Table II, Supersonic, contains, in addition, quantities relating the dynamic pressure, the Mach angle, and the angle-of-turning through a Prandtl-Meyer expansion. Table III, Normal Shock Waves, correlates pressure, density, temperature, and velocity with the Mach Number upstream and downstream of the shock wave. Although the values are for normal shock waves, many of the columns apply equally to oblique shock waves. Five appendixes give the formulas for: the viscosity of air, the Reynolds Number, humidity relations, a compilation of conversion factors and constants, and the variations of the temperature, pressure, and density of the N.A.C.A. Standard Atmosphere with altitude.

The Use of Source-Sink and Doublet Distributions Extended to the Solution of Arbitrary Boundary Value Problems in Supersonic Flow. Max A. Heaslet and Harvard Lomax. *U.S., N.A.C.A., Technical Note No. 1515*, January, 1948.

A new type of improper integral introduced by Hadamard is applied. The analogue with subsonic flow is maintained throughout all development. Examples of the application of the method include the solution of the load distribution for rolling and pitching delta wings swept ahead of the Mach cone.

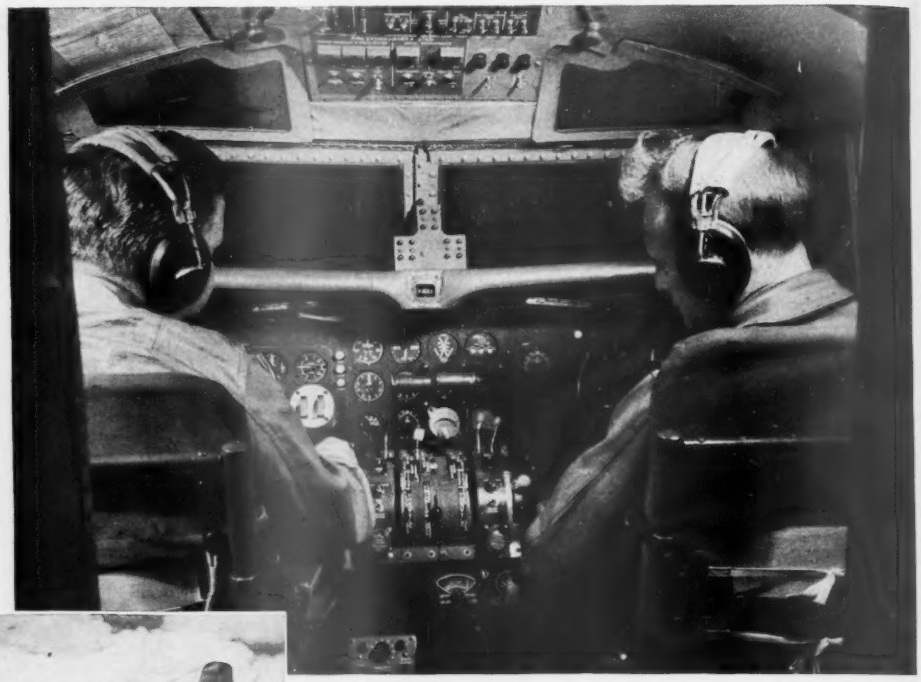
Linearization of Solutions in Supersonic Flow. John W. Tukey. *Quarterly of Applied Mathematics*, Vol. 5, No. 3, October, 1947, pp. 361–364, table. Theoretical and empirical justification for "linearizing the answer" rather than "linearizing the equations" in some fields of supersonic flow.

Numerical Determination by Use of Special Computational Devices of an Integral Operator in the Theory of Compressible Flow. II—Determination of the Coefficients of the Integral Operator by Interpolatory Means. Rufus Isaacs. *Journal of Mathematics and Physics*, Vol. 26, No. 3, October, 1947, pp. 165–179, tables. 7 references. (Cf. AER 7/47:34.)

The integral operator introduced by Bergman for the calculation of two-dimensional subsonic flow patterns of a compressible fluid are presented in a reduced form in which they have a range and domain suitable for computational purposes. The functions are defined by a recurrence relation involving derivatives and integrals. They are to be computed by replacing them by expressions involving nothing more than a finite number of arithmetical operations. Such a replacement involves an error, the precise bounds for which are given when the formula form is used and when the tabular form is used.

New Formulations of the Equations for Compressible Flow. B. L. Hicks, P. E. Guenther, and R. H. Wasserman. *Quarterly of Applied Mathematics*, Vol. 5, No. 3, October, 1947, pp. 357–361, fig. 10 references.

The thermodynamic characteristics of the flow pattern downstream of combustion occurring in an inviscid fluid that is in steady adiabatic flow are expressed in terms of the Mach vector and the Crocco vector.



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• **PERFORMANCE PLUS!** The Martin 2-0-2 boasts unusual stability in flight . . . cruises at 100 m.p.h. faster than the twin-engine planes it replaces, at full gross weight of 39,900 pounds . . . can climb 1410 ft. per minute . . . has service ceiling of 25,900 ft. . . . owes much of its high performance to new, efficient Martin wing, flaps, ailerons. Unusual ground maneuverability is possible through steerable nose wheel.

• **PLEASES PILOTS!** Martin 2-0-2 can take off at full gross weight, over 50 ft. obstacle, in 2230 ft. Unusually wide center of gravity range eliminates loading problems. Mareng flexible fuel tanks, located outboard of engines and away from cabin, help minimize mental hazard. Exceptional stability and control characteristics make 2-0-2 easy to fly . . . require minimum effort on pilot's part with maximum response.

Easy-to-Fly Martin 2-0-2 Designed for Pilot Satisfaction

UNUSUAL cockpit convenience, visibility and comfort, plus superior flying characteristics, make the Martin 2-0-2 the easiest aircraft of its type to handle. In mockup stages, Martin pilots worked with design engineers. Then experienced airline pilots inspected cockpit and made suggestions. Result: a cockpit *for* pilots, designed *by* pilots.

Pilot advantages of the 2-0-2 include heat anti-icing for wing, tail surfaces and propellers . . . quick, easy emergency gear extension, securely locked by gravity and airload . . . new Martin positive-control gust lock, instantly engaged on ground, simply released, providing complete safeguard against taking off with locked controls.

Pilot fatigue is reduced by efficient arrangement of cockpit controls and instruments. With this simple, logical arrangement, first things come first, giving a natural sequence of movements that minimize fatigue. Pilot may thus conserve energy for in-flight periods when maximum alertness is required. The Glenn L. Martin Company, Baltimore 3, Md.

Martin
AIRCRAFT
Builders of Dependable Aircraft Since 1909

On the Flow Patterns Common to Certain Classes of Plane Fluid Motions. D. Gilbarg. *Journal of Mathematics and Physics*, Vol. 26, No. 3, October, 1947, pp. 137–142.

All incompressible flows are determined which have the same streamlines as an arbitrary given incompressible fluid. All such geometrically identical flows have strictly proportional velocity vector fields, except those flows having constant velocity on streamlines. This result is applied to determine all those flows that at the same time have the flow patterns of possible potential flows of an incompressible fluid. Compressible and incompressible flows are shown to have in common two classes of motion, the flow patterns corresponding to circular vortex and radial (source or sink) flows.

Flow of a Compressible Fluid About a Cylinder. T. M. Cherry. *Royal Society of London, Proceedings, Series A*, Vol. 192, No. 1028, December 23, 1947, pp. 45–79, figs. 2 references.

A family of solutions is found for the two-dimensional flow of a compressible perfect fluid about a cylinder. The restriction is imposed that the circulation is zero and that the speed at large distances from the cylinder is subsonic. The hodograph method is used. The velocity components are taken as independent variables and the field equation is linear. In order to represent those portions of the flow field in which the vector velocity is less than the velocity at infinity, the hypergeometric function for vector velocity is expressed by a convergent series whose leading term represents the function asymptotically. A detailed critique justifies the author's disagreement with the method employed by Tsien and Kuo in a similar investigation.

On a New Method for Calculating the Potential Flow Past a Body of Revolution. Carl Kaplan. *U.S., N.A.C.A., Advance Restricted Report (Wartime Report No. L-558)*, July, 1942. 47 pp., figs. 3 references.

The Flow of an Ideal Incompressible Fluid About a Lens. Max Shiffman and D. C. Spencer. *Quarterly of Applied Mathematics*, Vol. 5, No. 3, October, 1947, pp. 270–288, figs. 5 references.

The velocity potential function of the irrotational flow produced by the motion of an immersed lenticular object is determined explicitly. The potential function of a lens formed by two intersecting spheres moving in the direction of its axis of symmetry is continued analytically as far as possible across the two faces of the lens to determine its singularities. The extended function is then defined over a multisheeted Riemann space with the sharp rim of the lens, the circle of intersection of the two spheres, as the branch line around which the Riemann space winds. In the analysis singularities are not only located at the inverted points but also at the points at infinity in the various sheets. It is necessary, therefore, to construct fundamental potential functions defined on the multisheeted Riemann space which have prescribed singularities at given points. The construction is a development of the case in which two spheres do not intersect, the procedure for which was introduced by A. Sommerfield in his work on the theory of diffraction where he considers a similar question for reflection across plane surfaces.

The Turbulent Flow Along a Semi-Infinite Plate. P. Y. Chou. *Quarterly of Applied Mathematics*, Vol. 5, No. 3, October, 1947, pp. 346–353. 6 references.

An analysis to establish the consistency of the author's treatment of turbulent flows with von Kármán's logarithmic law of velocity distribution. The shearing stress is shown to be constant across the turbulent boundary layer if the Reynolds Number of the flow is sufficiently high. The importance that is assumed by the triple velocity correlation within the turbulent boundary layer indicates that turbulence is generated in this layer and transported away from it. Since the triple velocity correlation is a measure of this transport, the set of equations governing the behavior of the correlation is needed for the interpretation of the velocity distribution. In spite of the fact that theoretical computations of the mean squares of turbulent fluctuations are not given, it is apparent that a certain type of function for the mean velocity distribution is necessary. The temperature distribution within the boundary layer of a heated plate can be calculated from the equations of mean temperature and of the double and triple velocity and temperature correlations.

INTERNAL FLOW

The Present Basis of Axial Flow Compressor Design. I—Cascade Theory and Performance. A. R. Howell. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2095*, June, 1942. 32 pp., diagrs. 25 references. British Information Services, New York. $1.90.

An analysis and comparison with low- and high-speed wind-tunnel test data of methods of designing axial flow compressors. For low-speed cascade tests with a given pitch-chord ratio and air outlet angle, the stalling deflection of the air appears within certain limits to be more or less independent of the camber and shape of the airfoil. The dependence of the stalling deflection on only two parameters has permitted some simple curves to be deduced for the variation of this deflection. The effect of Mach Number on compressor cascades is closely related to the ratio of the throat area between neighboring airfoils to the inlet flow area. Values of this ratio less than 1:1 should be avoided. The test results are given in a few simple design curves from which the performance of most present-day cascades can be obtained over a considerable range of incidence, Reynolds Number, and Mach Number. A reasonable correlation is shown to exist between the results obtained with cascade tests and with diffuser tests.

Experimental Investigation of Velocity Distributions Downstream of Single Duct Bends. John R. Weske. *U.S., N.A.C.A., Technical Note No. 1471*, January, 1948. 39 pp., illus. 4 references.

Contains measurements at Reynolds Numbers from 0.2 to 0.6 by 10^6 at the outlet of duct elbows of round, elliptical, square, and rectangular cross section. Three distinctive regions of flow in curved ducts were investigated by different techniques of measurement. Results indicate that cross-sectional shape and aspect ratio are minor factors compared with radius ratio in affecting the velocity pattern. Variation of Reynolds Number within the range of the tests had no appreciable effect on the velocity distribution in curved ducts.

Tests of a Jet-Motor Air-Intake Duct System on a $^1/_4$-Scale Stub-Wing Model of a Pursuit-Type Airplane. Frederick H. Hanson, Jr. *U.S., N.A.C.A., Memorandum Report No. A6A09 (Wartime Report A-85)*, May, 1946. 68 pp., illus. 1 reference.

Wind-Tunnel Investigation of a High-Critical-Speed Fuselage Scoop Including the Effects of Boundary Layer. Norman F. Smith and Donald D. Baals. *U.S., N.A.C.A., Advance Confidential Report No. L5B01a (Wartime Report No. L-733)*, February, 1945. 54 pp., illus. 5 references.

On the Velocity Distribution of Turbulent Flow in Pipes and Channels of Constant Cross Section. Chi-Teh Wang. Comment by R. B. Montgomery. *Mechanical Engineering*, Vol. 69, No. 11, November, 1947, p. 950. 3 references.

PARASITIC COMPONENTS & INTERFERENCE

Some Lift and Drag Measurements of a Representative Bomber Nacelle on a Low-Drag Wing. Macon C. Ellis, Jr. *U.S., N.A.C.A., Confidential Bulletin (Wartime Report No. L-695)*, May, 1942. 7 pp., illus. 1 reference.

Effects of a Typical Nacelle on the Characteristics of a Thick Low-Drag Airfoil Critically Affected by Leading-Edge Roughness. Macon C. Ellis, Jr. *U.S., N.A.C.A., Confidential Bulletin No. 3D27 (Wartime Report No. L-698)*, April, 1943. 10 pp., diagrs. 5 references.

PERFORMANCE

Drag Analysis of Performance Obtained at Aircraft and Armament Experimental Establishment on Various Aircraft, With Particular Reference to Slipstream Corrections. W. J. D. Annand and A. K. Weaver. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2168*, March, 1943. 15 pp., figs. 6 references. British Information Services, New York. $1.00.

Flight-test data obtained with four different aircraft were analyzed to determine the drag in level flight and in partial climbs. Discrepancies in these two measurements which had been previously noted were attributed to inadequate correction for the influence of the slipstream. Test results were inconclusive.

Spin Tests of a 0.058-Scale Model of the Curtiss-Wright XP-55 Airplane. George F. MacDougall, Jr., and Leslie E. Schneiter. *U.S., N.A.C.A., Memorandum Report No. L5G31a (Wartime Report No. L-650)*, August, 1945. 40 pp., illus. 4 references.

Test of $^1/_{16}$-Scale Wind-Tunnel Model Brewster XA-32. E. L. Davis and D. W. Young. (Five-Foot Wind-Tunnel Test No. 432.) *U.S., Army Air Forces, Technical Report No. 5130*, August 4, 1944. 35 pp., illus. 15 references.

STABILITY & CONTROL

Control in Flight Under Asymmetric Power: The Aerodynamics of the Problem of Regaining and Maintaining Control After Engine Failure. A. H. Yates. *Aircraft Engineering*, Vol. 19, No. 223, September, 1947, pp. 287–290, diagrs.

Flight Measurements of the Flying Qualities of an F6F-3 Airplane (BuAer No. 04776). I—Longitudinal Stability and Control. Walter C. Williams and John P. Reeder. *U.S., N.A.C.A., Memorandum Report No. L5B13 (Wartime Report No. L-715)*, February, 1945. 48 pp., illus. 3 references.

Effect of Tilt of the Propeller Axis on the Longitudinal-Stability Characteristics of Single-Engine Airplanes. Harry J. Goett and Noel K. Delany. *U.S., N.A.C.A., Report No. 774*, 1944. 28 pp., illus. 7 references. U.S. Govt. Printing Office, Washington. $0.20.

A Theoretical Investigation of the Rolling Oscillations of an Airplane With Ailerons Free. Doris Cohen. *U.S., N.A.C.A., Report No. 787*, 1944. 12 pp., figs. 7 references. U.S. Govt. Printing Office, Washington. $0.15.

Power-Off Wind-Tunnel Tests of the $^1/_8$-Scale Model of the Brewster F2A Airplane. John G. Lowry. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-543)*, June, 1941. 30 pp., diagrs.

Determination of the Stability and Control Characteristics of Airplanes From Tests of Powered Models. Isidore G. Recant and Robert S. Swanson. *U.S., N.A.C.A., Advance Restricted Report (Wartime Report No. L-710)*, July, 1942. 78 pp., illus. 15 references.

Flight Tests of an SB2C-3 Airplane With a Production and Tilted Propeller Axis. R. Fabian Goranson. *U.S., N.A.C.A., Memorandum Report No. L5E19a (Wartime Report No. L-675)*, May, 1945. 31 pp., illus. 3 references.

Tests in the 19-Foot Pressure Tunnel of a $^1/_{2.75}$-Scale Model of the F4U-1 Airplane With Several Balanced Elevators, Full-Span Flaps, and Droppable Gas Tank. Robert R. Graham and C. Dixon Ashworth. *U.S., N.A.C.A., Advance Confidential Report (Wartime Report No. L-440)*, October, 1942. 50 pp., illus.

WINGS & AIRFOILS

A Method of Aerofoil Design. I—Symmetrical Aerofoils. II—Cambered Aerofoils. B. Thwaites. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2166, 2167*, May, September, 1945. 9, 13 pp., figs. 7, 8 references. British Information Services, New York. $0.70, $0.90.

I. A method of designing conventional symmetrical airfoils of thickness less than 20 per cent when the velocity is given as a set of numerical values at certain points on the chord. The computational work is completely standardized, requires no mathematical technique, and is the same for any type of airfoil. The method is applied to the case in which the coefficient of lift is zero. The method can be used to design for lift coefficients other than zero but requires a certain amount of airfoil experience to estimate ψ. Two examples illustrate the application to the design of a particular airfoil.

II. The method above, when extended to the design of cambered airfoils, aside from its simplicity, has the advantage that the most efficient camber line is automatically used, since the fairing and the camber line are designed independently. Whatever the shape of the camber line, the amount of computation required remains constant. The development of the airfoil AN420-109 is traced in detail to show the application of this method.

Formulae for the Computation of the Functions Employed for Calculating the Velocity Distribution About a Given Aerofoil. E. J. Watson. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2176*, May, 1945. 7 pp., table. 2 references. British Information Services, New York. $0.70.

When ψ is given numerically, it is necessary to evaluate the functions ψ', ϵ, and ϵ'. If the values of ψ are specified at $2N$ points equally spaced about the circle into which the airfoil has been transformed, the formulas developed here may be used to calculate these functions at the same points. Formulas are given for calculating the integrals of ψ or ϵ since these have application to the design of airfoils by Thwaites's numerical method. The simplicity of the formulas for ψ', ϵ, and ϵ' makes it possible to determine readily the effect of a local change of shape on velocity distribution, by making N sufficiently large. Coefficients for the case $N = 20$ are tabulated.

The Estimation of Aerofoil Lifting Characteristics; The Derivation and Application of Methods Developed in the R.A.E. P. L. Bisgood. *Aircraft Engineering*, Vol. 19, No. 223, September, 1947, pp. 278–286, figs. 14 references.

Theoretical Critical Mach Numbers for NACA 16 Series Aerofoils. E. J. Richards. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2170*, July, 1945. 8 pp., figs. 4 references. British Information Services, New York. $0.70.

The Stability Derivatives of Low-Aspect Triangular Wings at Subsonic and Supersonic Speeds. Herbert S. Ribner. *U.S., N.A.C.A., Technical Note No. 1423*, September, 1947. 34 pp., figs. 7 references. (Note: The abstract published in the December, 1947, issue contained several errors. The corrected abstract follows.—Rev. Ed.)

Low-aspect-ratio wings having triangular plan forms are treated on the assumption that the flow potentials in planes at right angles to the long axis of the airfoils are similar to the corresponding two-dimensional potentials. Pressure distributions caused by downward acceleration, pitching, rolling, sideslipping, and yawing are obtained for wings with and without dihedral. The stability derivatives calculated from these distributions are expected to apply at both subsonic and supersonic speeds, with the exception of the transonic region, up to a limiting speed at which the triangle is no longer narrow compared with the Mach cone from its vertex.

A Flight Investigation of the Boundary-Layer Characteristics and Profile Drag of the NACA 35-215 Laminar-Flow Airfoil at High Reynolds Numbers. J. W. Wetmore, J. A. Zalovcik, and Robert C. Platt. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-532)*, May, 1941. 22 pp., illus. 3 references.

Two-Dimensional Wind-Tunnel Investigation of Two NACA Low-Drag Airfoil Sections Equipped With Slotted Flaps and a Plain NACA Low-Drag Airfoil Section for XF6U-1 Airplane. Lawrence K. Loftin, Jr., and Fred J. Rice, Jr. *U.S., N.A.C.A., Memorandum Report No. L5L11 (Wartime Report No. L-746)*, January, 1946. 23 pp., diagrs. 2 references.

Lift and Drag Characteristics of a Low-Drag Airfoil With Slotted Flap Submitted by Curtiss-Wright Corporation. I. H. Abbott. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-703)*, December, 1941. 6 pp., figs.

Stability and Control Force Tests of Four- and Six-Unit Wing Designs of Low Aspect Ratio and 20° Triangular Plan Form. John L. Paulson, Joseph L. Johnson, and Elizabeth P. Varney. *U.S., N.A.C.A., Advance Confidential Report No. L6D17a (Wartime Report No. L-734)*, May, 1946. 31 pp., illus. 3 references.

Wings for High Speed Flight. William Morse. *Aeronautics*, Vol. 17, No. 4, November, 1947, pp. 79, 80, 83, 84, 87, diagrs. A mathematical exposition of critical Mach Number, aspect ratio, and sweepback to flight at transonic and supersonic speeds.

Air Power

Civil Aviation and Air Power. Maxwell W. Balfour. *Southern Flight*, Vol. 28, No. 5, November, 1947, pp. 20, 36. The role of fixed-base operators and private aviation.

Hemispheric Defense Important to World Peace. J. Carlton Ward, Jr. *The Pegasus*, Vol. 10, No. 6, December, 1947, pp. 6, 7, illus.

The Future of Air Power Must Be Carefully Planned. Emory S. Land. *The Pegasus*, Vol. 10, No. 6, December, 1947, pp. 1–5, illus.

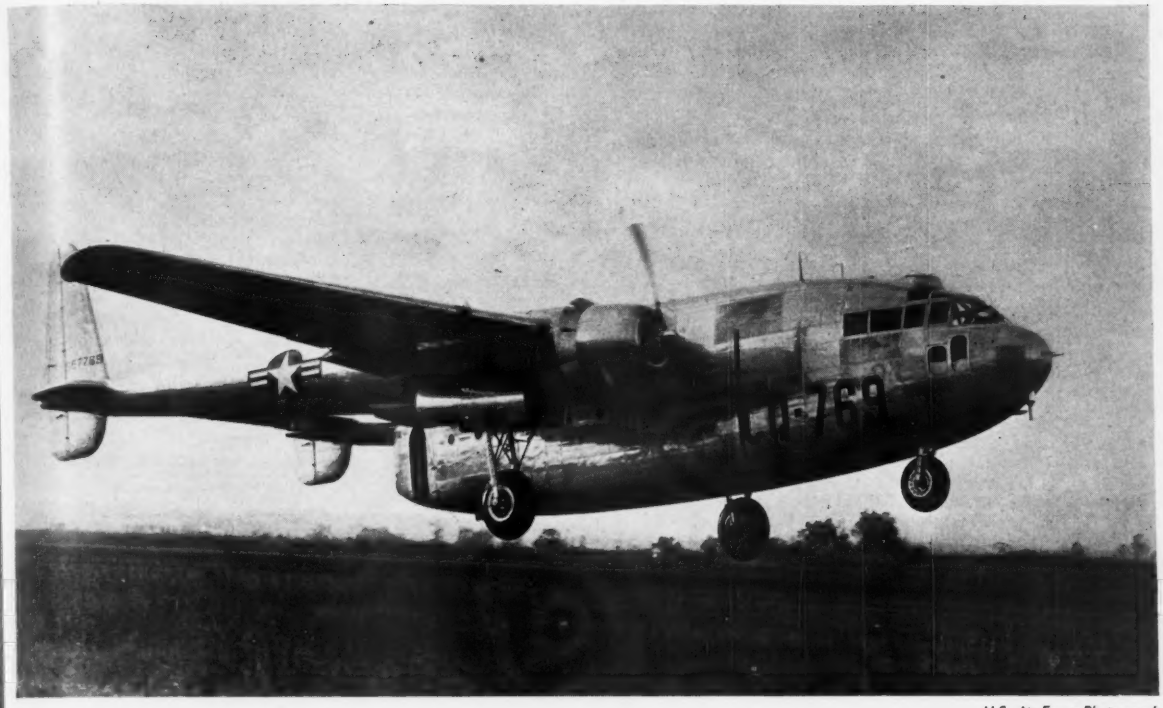
The Aircraft Industry States Its Case. Robert McLarren. *Automotive Industries*, Vol. 97, No. 11, December 1, 1947, pp. 40–42, table.

Overall summary of the recommendations made to the President's Air Policy Commission and abstracts of five statements submitted by aircraft company executives.

Airplane Design & Description

Freight Loading Facilities on Transport Aircraft; A Review of the Various Methods That Have Been Established. M. F. Allward. *Aircraft Engineering*, Vol. 19, No. 223, September, 1947, pp. 301–304, illus.

Proposed Fulfilment: The Designer of the Planet Satellite Discusses Sir Roy Fedden's New Ideal. J. N. D. Heenan. *Flight*, Vol. 52, No. 2027, October 30, 1947, pp. 493, 494, illus. (Cf. AER 1/48:37.)



U.S. Air Force Photograph

First official view of the Air Force's latest cargo transport, the Fairchild C-119. Powered with two Pratt & Whitney R-4360 Wasp Major engines, the C-119 can carry a 9-ton pay load 2,000 miles.

Spring Tabs. I—A Review of Their Development and Application, Together with an Outline of the Design Data Involved. F. B. Baker. *Aircraft Engineering*, Vol. 19, No. 224, October, 1947, pp. 314–319, diagrs.

A mathematical analysis of the forces acting on control surfaces and the modifications in these forces introduced by balance tabs. The mechanism and characteristics of the spring-, geared-, and servo-tab and torsion-bar mechanisms are calculated.

Some Recent Developments in the Landing Gear Field. Réné Lucien. *Paper presented before the Royal Aeronautical Society*, November 6, 1947. 50 pp., illus.

A discussion of general landing-gear practice. Increased landing and take-off speed and gross weight of aircraft have led to the adoption of the tricycle landing gear. The freely castoring nose wheel, the steerable nose wheel, and systems with all wheels castoring have been introduced to solve the problem of ground control. In French practice the Chausson, the Katz, and the Messier systems have been used to provide shock absorbers that will absorb the high impact force on landing and yet have sufficient resilience to provide smooth taxiing. Increased altitudes have required the adoption of fluids for hydraulic systems which will be effective at low temperatures. The brittleness of many alloys at low temperatures has also introduced additional strength problems. Light alloy castings and steel, when properly produced and fabricated, can overcome this difficulty. Thin wings require new methods of undergear retraction and shock absorber design.

Landing Gear Developments. Réné Lucien. *Flight*, Vol. 52, No. 2029, November 13, 1947, pp. 554–556, diagrs., Discussion, p. 556. (Extended abstract of a paper.)

Recent Undercarriage Developments. Réné Lucien. *The Aeroplane*, Vol. 73, No. 1901, November 14, 1947, pp. 645–648, illus. (Extended abstract of a paper.)

"Duck" Displays Cross-Wind Undercarriage (Goodyear 3-Place Amphibian). Ronald A. Keith. *Canadian Aviation*, Vol. 20, No. 11, November, 1947, pp. 26, 27, illus.

Snow Time is Ski Time on Canada's Air Lanes. *Aircraft and Airport*, Vol. 9, No. 12, December, 1947, pp. 20, 22, illus. History of the development of ski landing gear for aircraft by Federal Aircraft Works.

Ultra-Light Aircraft. Peter F. Murray. *The Aeroplane*, Vol. 73, No. 1898, October 24, 1947, pp. 555–557, illus. A review of personal plane designs since 1908.

A Report on Ultra Light Aviation. R. W. Clegg. *Aeronautics*, Vol. 17, No. 4, November, 1947, pp. 70–74, 77, 78, diagrs. General status of ultra-light aircraft activities and specifications of eight designs.

German High-Altitude Research. *The Aeroplane Spotter*, Vol. 8, No. 198, October 18, 1947, pp. 234–236, illus.

Some details of the research and operational high-altitude aircraft developed by the German aircraft industry. Development was directed to engine-boost equipment, cabin design and pressurization, pressure suits, and armament control.

The Anglo-American Aeronautical Conference; Impressions by M. Hodgson of the Papers Presented at the Combined Conference of the Royal Aeronautical Society and the Institute of Aeronautical Sciences Held in London, September, 1947. M. Hodgson. *Aircraft Engineering*, Vol. 19, No. 224, October, 1947, pp. 310–313, diagrs.

Britain's Aeronautical Achievement. *Aeronautics*, Vol. 17, No. 4, November, 1947, pp. 36–66, 99, illus.

A progress study based on the S.B.A.C. Radlett exhibition, September, 1947. Contains descriptions and specifications of the 53 airplanes, 11 gliders, and 20 engines exhibited; cutaway drawings of design details; four colored charts comparing statistics for 1938 and 1946; and directory.

French Two-Seat Light Aircraft. *The Aeroplane Spotter*, Vol. 8, No. 198, October 18, 1947, p. 232, illus. Tabulated specifications of 11 models.

The Grand Tour Up to Date. V. F. T. Meacock. *The Aeroplane*, Vol. 73, No. 1901, November 14, 1947, pp. 640–642, illus. Consists mainly of descriptions of the French S.N.C.A.S.E. transport flying boats S.E. 1200, S.E. 1010, S.E. 2010, and S.E. 200.

America's Jets: Diverse Military Applications: Two, Four, Six and Eight-Jet Bombers. *Flight*, Vol. 52, No. 2029, November 13, 1947, pp. 549–552, illus.

New Shapes in the Air. XXI—The Elliots Newbury Eon 1; The De Havilland DHC-2 Beaver. *The Aeroplane Spotter*, Vol. 8, No. 198, October 18, 1947, p. 233, illus.

New Shapes in the Air. XXIII—The Avro 652A Anson C. Mk XIX and the Boeing XB-47 Stratojet. *The Aeroplane Spotter*, Vol. 8, No. 200, November 15, 1947, p. 256, illus.

New Shapes in the Air. XXVII—The Boeing YL-15; The Douglas D-558-2 Skyrocket. *The Aeroplane Spotter*, Vol. 8, No. 202, December 13, 1947, p. 280, illus.

New Shapes in the Air. XXVIII—The North American XSN2J-1: The Percival Prentice T. Mk. 1. *The Aeroplane Spotter*, Vol. 8, No. 202, Dec mber 13, 1947, p. 281, illus.

The "Mambalanc" Delivered: Air Service Training Convert and Fly the First Mamba Test Bed. *Flight*, Vol. 52, No. 2027, October 30, 1947, pp. 487, 488, illus.

Private Owner Types. XVI—The Beechcraft Model 35 Bonanza. *The Aeroplane Spotter*, Vol. 8, No. 198, October 18, 1947, p. 237, illus.

Bonanza Vee-Tail Controls (Beech). *Aircraft and Airport*, Vol. 9, No. 12, December, 1947, p. 36, diagr.

Bell XS-1 Makes Supersonic Flight: Air Force and NACA Pilots Fly Beyond Mach No. 1 in Secret Muroc Tests; Report "No Undue Difficulties." Robert McLarren. *Aviation Week*, Vol. 47, No. 25, December 22, 1947, pp. 9, 10, illus.

Taxi Tests for Boeing Stratojet (XB-47). *Aviation Week*, Vol. 47, No. 21, November 24, 1947, p. 29, illus.

Utility for the Army (Boeing YL-15 Liaison Airplane). *Southern Flight*, Vol. 28, No. 5, November, 1947, pp. 14, 15, illus.

The Boulton Paul P. 108 (Advanced Military Trainer). *The Aeroplane*, Vol. 73, No. 1898, October 24, 1947, pp. 553, 554, illus.

Weather Reconnaissance and Training: The Bristol (164) Brigand Met. Mk. III and the Bristol (166) Buckmaster T. Mk. I. *The Aeroplane*, Vol. 73, No. 1901, November 14, 1947, p. 636, illus.

New Shapes in the Air. XXIV—The Bristol Type 170 Freighter XI and the Bristol Type 171 Mk. 1. *The Aeroplane Spotter*, Vol. 8, No. 200, November 15, 1947, p. 257, illus.

The Caproni-Campini C.C.2 (Jet Airplane). *The Aeroplane Spotter*, Vol. 8, No. 200, November 15, 1947, p. 262, illus.

Vampire, Hornet, and Mosquito (de Havilland). *Flight*, Vol. 52, No. 2029, November 13, 1947, p. 542, chart. Design and performance characteristics of variant models.

Three-Engine Design Wins Favor: Australians Latest to Adopt Configuration for "Bush" Operations with New de Havilland Drover Based on Two Earlier DH Craft. *Aviation Week*, Vol. 47, No. 52, December 22, 1947, p. 20, illus.

Ultra-Leichtflugzeug "Tipsy-Junior," das Kleinste Schulflugzeug der Welt (The Ultra-Light Fairey "Tipsy Junior," the Smallest Training Airplane in the World). *Schweizer Aero-Revue*, Vol. 22, No. 10, October, 1947, pp. 427, illus.

Latest Gruman Amphibian: Navy's XJR2F-1 Completes Preliminary Land and Water Flight Tests. *Aviation Week*, Vol. 47, No. 21, November 24, 1947, p. 15, illus.

The Hawker Fury Trainer (Developed from the Hawker Sea Fury X Naval Fighter). *The Aeroplane*, Vol. 73, No. 1898, October 24, 1947, p. 558, diagr.

Flying Boat; Largest Craft Undergoes Test Run (Hughes Flying Boat). *Aviation Week*, Vol. 47, No. 22, December 1, 1947, p. 24, illus.

Navy Buys 29 More Lockheed P2V Neptunes. *Naval Aviation News*, No. 8, December, 1947, p. 22, illus. Description of the new features incorporated in the P2V-2 twin-engined patrol bomber.

Engineering the (Luscombe) "Silvaire Sedan." H. F. Kueck. *Aero Digest*, Vol. 55, No. 6, December, 1947, pp. 46–48, illus.

Parasite Jet Fighter Due for Test (McDonnell XP-85). *Aviation Week*, Vol. 47, No. 22, December 1, 1947, p. 14, illus.

This Is the Two-O-Two (Martin 40-Passenger Transport). *Air Transport*, Vol. 5, No. 11, November, 1947, pp. 19–34, illus.

German Aircraft in Detail. XV—The Messerschmitt Me 262. *The Aeroplane Spotter*, Vol. 8, No. 202, December 13, 1947, p. 284, illus.

Aerovan Development. *Aircraft Engineering*, Vol. 19, No. 224, October, 1947, p. 335, illus.

The M-68 developed from the Aerovan by Miles Aircraft Ltd. is a four-engined freighter with a detachable freight compartment. When the freight section, which is the middle segment of the fuselage, is removed, the rear portion can be brought forward and attached directly to the nose section and the plane operated without a cargo load.

Die Zweimotorigen Taxiflugzeuge "Miles" der "Aerotaxi-Lufttaxi A.G.", Zürich (Miles Gemini). *Schwiezer Aero-Revue*, Vol. 22, No. 10, October, 1947, pp. 411–413, diagrs.

Progress With the Newbury Eon (Three-Seater). *Flight*, Vol. 52, No. 2027, October 30, 1947, p. 497, illus.

Ryan Brings Out Newly Styled Navion for 1948 Sales Campaign. Alexander McSurely. *Aviation Week*, Vol. 47, No. 21, November 24, 1947, pp. 37, 38, illus.

Saab Scandia. *Svenska Aeroplan AB*, Linköping, Sweden, 1947. 32 pp., illus.

A brochure on design, performance, and operating data of the Scandia 90A and 90B. The two models of this passenger transport differ with respect to the incorporation of cabin pressurization. They carry 24 to 32 passengers and have a range of 1,150 miles.

The Short S.45 Solent I (4-Engined Flying Boat). *The Aeroplane Spotter*, Vol. 8, No. 202, December 13, 1947, p. 285, illus.

Fighterboat (Saunders-Roe S.R. A/1 Jet Fighter Flying Boat). *Aeronautics*, Vol. 17, No. 4, November, 1947, pp. 88–92, illus. (Cf. AER 11/47:27.)

Airplane Operation

All-Weather Landing Descent. Ralph S. Johnson. *Air Transport*, Vol. 5, No. 11, November, 1947, pp. 41, 42, 87, 88, diagrs.

A description of the power-controlled approach. In conventional landings, when the pilot approaches the runway, he must take seven variables into consideration. By lowering landing flaps, trimming the aircraft, and assuming the desired landing speed as soon as possible after the airplane has been directed to the landing strip and the descent has begun, the variables are reduced to two. The altitude is controlled by power.

Flight Refuelling Increases Payloads. Basil Woodd. *Canadian Aviation*, Vol. 20, No. 11, November, 1947, pp. 34, 60, illus. The technique used by Flight Refuelling Ltd.

Airports & Airways

Airports in the Balance Sheet of Real Estate Values. George W. Burgess. *Address presented before the National Association of Real Estate Boards*, San Francisco, November 14, 1947. 9 pp.

Runway Standards. John H. Frederick. *Southern Flight*, Vol. 28, No. 5, November, 1947, pp. 26, 32. Discussion of C.A.A. proposed standards and recommendations for standards based on local economic factors and progress in airplane design performance.

Plain Talk About the (Federal) Airport Program. H. A. Hook. *Southern Flight*, Vol. 28, No. 5, November, 1947, pp. 24, 25, 34, illus.

Airports Under Snow. Arthur Macdonald. *Canadian Aviation*, Vol. 20, No. 11, November, 1947, pp. 24, 25, 66, illus. Summary of information on snow-removal equipment.

Wie Steht es mit dem Flughafen Zürich-Kloten? (What is the Situation at the Zurich-Kloten Airport?) *Schweizer Aero-Revue*, Vol. 22, No. 10, October, 1947, pp. 430, 431, diagr.

Aviation Medicine

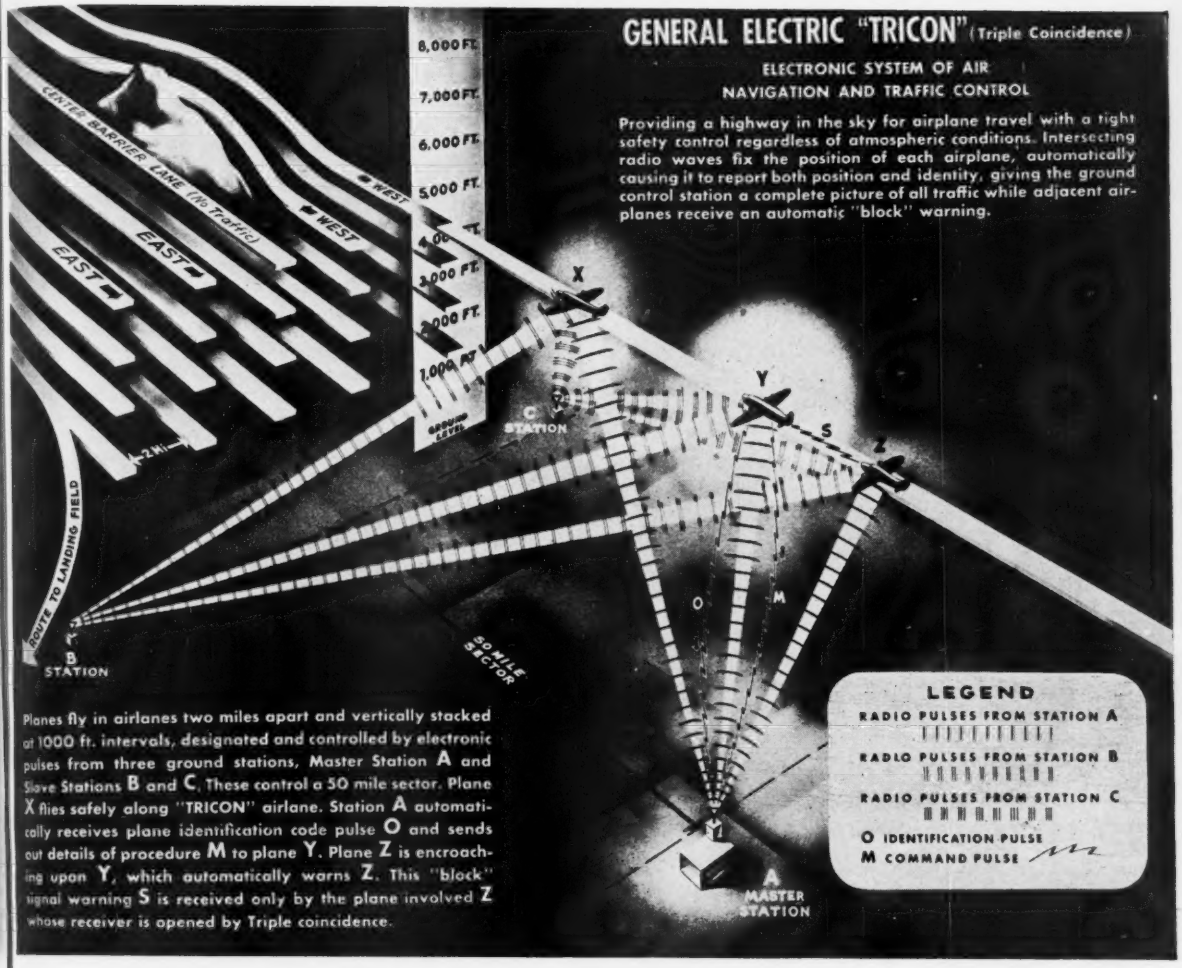
Psychological Aspects of Instrument Display. I—Analysis of 270 "Pilot-Error" Experiences in Reading and Interpreting Aircraft Instruments. Paul M. Fitts and R. E. Jones. *U.S., Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Memorandum Report No. TSEAA-694-12A*, October 1, 1947. 47 pp. 13 references.

A Study of the Accuracy of Recognition of the Incipient Stall in Familiar and Unfamiliar Planes. P. J. Rulon. *U.S., Civil Aeronautics Administration, Division of Research, Report No. 74*, November, 1947. 135 pp., illus.

Investigation of 254 pilots showed a marked lack of accuracy in recognizing incipient stall. Also that the pilot frequently approached stalling conditions inadvertently.

Action of Benzedrine Compounds of Tolerance of Anoxia. R. Margaria. (*Rivista di Medicina Aeronautica*, Vol. 4, No. 2, June, 1947.) *U.S., Army Air Forces, Library (Washington), Translation No. 393*, December 12, 1945. 20 pp., figs. 28 references.

Despite the opinions of other authors, the results of tests made on 13 subjects showed that benzedrine preparations reduce the pulmonary ventilation and consequently diminish tolerance of anoxia.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Comfortization

Inside Tomorrow's Airliner. B. J. Cumnock. *Air Transport*, Vol. 5, No. 11, November, 1947, pp. 43–45, illus.

Survey of developments in seat design, cabin decoration, appointments, and facilities now being provided for the comfort of passengers traveling long distances.

Electronics

More "On Time" Schedules. *Air Transport*, Vol. 5, No. 11, November, 1947, pp. 39, 40, diagrs.

A summary of a paper, "The Application of Existing Techniques to Development of an Improved System of Air Traffic Control," by Warren D. White of the Airborne Instruments Laboratory. A complete coverage of the airways with omnirange and distance-measuring navigational facilities could improve existing air-traffic conditions without the use of radar.

Position-Finding by Radio; First Thoughts on the Classification of Systems. C. E. Strong. *The Engineer*, Vol. 184, No. 4789, November 7, 1947, pp. 446, 447, figs. (Cf. AER 2/48:45).

Frequency Stabilization of Microwave Oscillators by Spectrum Lines. William V. Smith, José L. García de Quevedo, R. L. Carter, and W. S. Bennett. *Journal of Applied Physics*, Vol. 18, No. 12, December, 1947, pp. 1112–1115, diagrs. 5 references.

The cavity of Pound's direct-current cavity stabilizer circuit is replaced by an arm containing gas under low pressure. The electrical length of the gas arm is $x = \lambda g/8$. Ammonia was used as the gas. The output of the discriminator was fed back to a 2K50 klystron tieing it to the NH_3 3.3 spectrum line at 23,870 mc. Control was maintained for variations in reflector voltage equivalent to a frequency spread of just under 51 mc.

The Efficiency of Thermo-Electric Generators. I. Maria Telkes. *Journal of Applied Physics*, Vol. 18, No. 12, December, 1947, pp. 1116–1127, figs. 52 references. Survey of the efficiency of thermoelectric couples. An efficiency of 7 per cent was obtained with a lead sulphide-constantan generator.

Improvements in the Construction of Cathode-Ray Tubes. J. de Gier and A. P. van Rooy. *Philips Technical Review*, Vol. 9, No. 6, 1947, pp. 180–184, illus.

The Electrical and Technical Ceramic Industry of Germany; Supplementary Report (High Dielectric Constant Insulators). Bennett S. Ellefson. *U.S., Field Information Agency, Technical, F.I.A.T. Final Report No. 617 (Supplement No. 1)*, January 31, 1947. 18 pp. 4 references. British Information Services, New York. $0.70.

What To Do When the Radio Won't Work. Harvey A. Senior. *Aviation Service Magazine*, November, 1947, pp. 14–18, 33, 54, 62, diagrs.

Engineering Practices & Aids

New Machine Speeds Templating; Automatic Sensitizer, Conveyor System Aid Production by Making Templates Available Shortly After Master Drawing Completed. *Aviation Week*, Vol. 47, No. 22, December 1, 1947, pp. 20, 23, illus.

Equipment

German Aircraft Heat Exchanger Equipment. R. G. Hutchings. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 1339, Item No. 25.* 50 pp., illus. British Information Services, New York. $1.75.

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Ducts; Any Shape or Size. *Boeing Magazine*, Vol. 17, No. 12, December, 1947, pp. 8, 9, illus.

Description of the manufacture of plastic ducts used in the air-conditioning and thermal deicing systems of the Boeing Stratocruiser and the YC-97B. The ducts made of Fiberglas impregnated with a resin are lighter, less expensive, and, because of the smaller number of joints, are less sensitive to vibration.

ELECTRICAL

Experiences With Aluminum Electrical Conductors in Aircraft (Project No. XQ 13). B. M. G. Wolfframm. *U.S., Army Air Forces, Summary Report No. F-S U-1156-ND (GS-A A F-Wright Field No. 46)*, November, 1947. 11 pp., diagrs.

The principal problem presented by the use of aluminum conductors was corrosion at terminals. The use of bimetallic sleeves on the cable and the use of lock washers at the terminal was expected to solve the problem.

Electrical Equipment and Accessories for Japanese Aircraft. A. D. Dircksen. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./116*, November 6, 1945. 9 pp., diagr. New York, British Information Services. $0.45.

Relay Design for Compactness. T. B. Holliday. *Product Engineering*, Vol. 18, No. 12, December, 1947, pp. 118–121, illus.

Theory of Cranking Motor Operation. William H. Crouse. *Aviation Service Magazine*, December, 1947, pp. 24, 25, 28, 30, 44, diagrs.

Flight Testing

Instrumentation of Aircraft as Used by the Flight Test Division. Emil Henrich. *U.S., Army Air Forces, Technical Report No. 5551*, February 21, 1947. 103 pp., illus., diagrs.

A detailed tabulation and illustrated description of the instruments and equipment that must be installed in an aircraft to supply adequate flight-test data on aircraft performance and stability and power-plant performance. Diagrams and sketches show schematic arrangement and optimum location.

Flight Testing Methods of the Japanese Navy. J. H. Morse, Jr. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./131*, November 12, 1945. 5 pp. British Information Services, New York. $0.25. Outline of procedures and instrumentation.

Telemetering Offers New Benefits in Civil Plane Test and Operation. *Aviation Week*, Vol. 47, No. 21, November 24, 1947, pp. 31, 32, 34, 35, figs.

A report by Martin V. Kiebert, Jr., points out the potentialities of telemetering, which, to date, has had its principal application in flight testing. It permits a more liesurely reading of flight-test data and, in the case of accidents in which the flight instruments are destroyed, supplies a permanent record of the behavior of the aircraft. Data thus obtained have an accuracy comparable to that of conventional flight instruments. However, the high frequencies used impose the limitation of line of sight transmission. This restriction and the great amount of time required for data reduction are obstacles that make its use inefficient except for those tests that cannot be accurately simulated and evaluated on the ground.

Flight Measurements by Various Methods of the Drag Characteristics of the XP-51 Airplane. Henry A. Pearson and Dorothy E. Beadle. *U.S., N.A.C.A., Memorandum Report No. L6F12 (Wartime Report No. L-741)*, June, 1946. 28 pp., illus. 9 references.

Fuels & Lubricants

A Comparison of the Starting Characteristics of 1100 Grade Aviation Oils. Walter L. Hardy and Julian M. Hirsch. *U.S., Army Air Forces, Technical Report No. 5320*, November 8, 1945. 446 pp., figs.

A study of pour points and cranking speeds predicted from viscosity measurements of a series of 1100 grade aviation oils (Specification AN-O-5) derived from high (97–105) and medium (70–85) viscosity index stocks. The stocks were dewaxed to pour points ranging from +50°F. to —15°F., contained from 0 to 5 per cent of Paraflow or Stantopour pour depressants, and were diluted up to 30 per cent with gasoline. The use of 30 per cent dilution ensured flow and cranking characteristics satisfactory for

the starting of aviation engines at temperatures as low as −65°F. Proportionate amounts of dilution were found to be satisfactory at intermediate temperatures between +10°F. and −65°F.

Alkylbenzenes in the C_8 Fraction From Five Different Catalytic Petroleum Refining Processes. Anton J. Streiff and Frederick D. Rossini. *U.S., National Bureau of Standards, Journal of Research*, Vol. 39, No. 4, October, 1947, pp. 303–308, figs. 7 references. Available also as *Research Paper No. RP1830*, U.S. Govt. Printing Office, Washington. $0.10.

Purification, Purity, and Freezing Points of *n*-Decane 4 Alkylcyclopentanes, 9 Alkylcyclohexanes, 2 Monoolefins, 1,2-Butadiene, and 2-Butyne of the API-Standard and API-NBS Series. Anton J. Streiff, Evelyn T. Murphy, and others. *U.S., National Bureau of Standards, Journal of Research*, Vol. 39, No. 4, October, 1947, pp. 321–349. 8 references. Available also as *Research Paper No. RP1833*, U.S. Govt. Printing Office, Washington. $0.15.

Butane Used as Fuel in Lightplane Flight. *Aviation Week*, Vol. 47, No. 21, November 24, 1947, p. 25.

An Electric Study of Boundary Lubrication; Further Rolls-Royce Investigations Tending to Confirm Deductions From Previous Tests. V. H. Brix. *Aircraft Engineering*, Vol. 19, No. 223, September, 1947, pp. 294–297, diagrs.

Application of Viscosity Measurement in Petroleum Refining Operations. D. J. Pompeo. *Instruments*, Vol. 20, No. 11, November, 1947, pp. 1002, 1003. 4 references.

A discussion of the refinery control points at which the use of continuous-recording or direct-reading viscometers would increase the efficiency of refining operations.

Gliders & Gliding

New Finnish Single-Seat Trainer; PIK-5 "Cumulus." *Sailplane and Glider*, Vol. 15, No. 12, December, 1947, pp. 15–17, illus.

Aircraft in Detail. LXXIV—The Short Nimbus Sailplane. *The Aeroplane Spotter*, Vol. 8, No. 200, November 15, 1947, p. 262, cutaway drawing.

Guided Missiles

Fundamental Aerodynamic Investigations for Development of Arrow-Stabilized Projectiles. Hermann Kurzweg. (*Deutsche Akademie der Luftfahrtforschung, Schriften Nr. 1059*, pp. 33–71, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1175*, December, 1947. 46 pp., illus.

A discussion of the design problems presented by missiles that are stabilized by fins instead of by spinning, with particular reference to problems at supersonic Mach Numbers. The pressure distribution over a missile and its fins at both subsonic and supersonic Mach Numbers was obtained from wind-tunnel measurements. The experimental drag coefficient is given for various body shapes at a Mach Number of 2.5 and zero angle of attack.

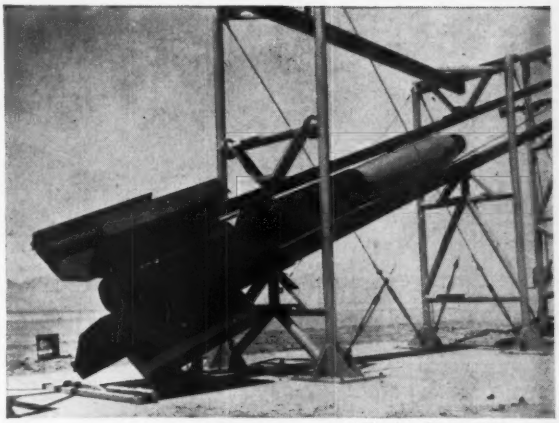
Point Mugu (Naval Air Missile Test Center); Where They Make Almost Anything Fly. *The Martin Star*, December, 1947, pp. 7, 8, 16, illus.

Ice Prevention

First Interim Report on Icing Investigation of Turbo-Jet Engines; Preliminary Icing Experiments with an Axial-Flow Unit on the Test Stand. J. J. Samolewicz and G. A. Macaulay. *Canada, National Research Council, Report No. ME-159*, September 1, 1947. 79 pp., illus.

Detailed description of the test set up, test conditions, and effect on engine performance. Ice formed on the starter fairing, blocking the compressor inlet and producing excessive tailpipe temperatures and loss of thrust. Ice formed also on the compressor guide vanes. Ice that broke off the formations and entered the compressors in some cases did considerable damage to the compressor rotor.

The Calculation of the Heat Required for Wing Thermal Ice Prevention in Specified Icing Conditions. Carr B. Neel, Jr., Norman R. Bergrun, David Jukoff, and Bernard A. Schlaff. *U.S., N.A.C.A., Technical Note No. 1472*, December, 1947. 107 pp., illus. 26 references.



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Flight tests in natural-icing conditions were made with two 8-ft.-chord heated airfoils of different sections. Previously derived equations for calculating the rate of heat transfer from airfoils in icing conditions were verified. Knowledge of the manner in which water is deposited on, and evaporated from, the surface of a heated airfoil was expanded sufficiently to allow reasonably accurate calculations of airfoil heat requirements. Knowledge of the meteorology of icing and the process of ice prevention has been increased to a point where the design of heated wings on a fundamental, wet-air basis now can be undertaken with reasonable certainty.

Anti-Icing System of Ju 288 Heavy Bomber. Paul Hentrich. (*Göttingen, Aerodynamische Versuchsanstalt*, July, 1942.) *U.S., Air Force, Translation No. F-TS-1908-RE*, January, 1948. 32 pp., illus.

Modifications were made to conserve heat and to obtain periodic deicing instead of anti-icing. The new system consists of highly heated strips on the stagnation line. The old and new systems are compared for the heat required and for efficiency.

NACA Research Ends Ice Hazard; Award of Robert J. Collier Trophy to Committee Engineer Caps 20-Year Effort to Prevent Ice Formation on Any Part of Plane. Robert McLarren. *Aviation Week*, Vol. 47, No. 52, December 22, 1947, pp. 24–25, 27, illus.

Type Test of Propeller Electrical Deicing Generator Model D-11. D. C. Haynes, Jr. (*Whirl Test No. 1770.*) *U.S., Army Air Forces, Technical Report No. 5553*, February 18, 1947. 13 pp., illus.

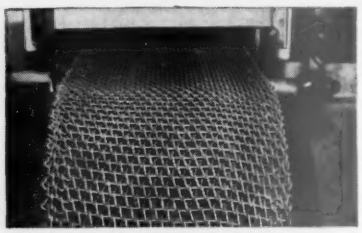
Installations

UNDERGROUND

German Underground Installations. II—Adaptations of Existing Facilities. III—Various Installations of General Interest. *Joint Intelligence Objectives Agency, Final Report Nos. 2, 6*, September, 1945. 46, 110 pp., diagrs. British Information Services, New York. $1.45, 3.50.

II. Description of the layout, design, and construction of 57 installations. Mines, railroad, and highway tunnels, brewery vaults, and caves were utilized. Notes are made on the ventilation and drainage systems, shoring, lining, seepage prevention, utilities, and accommodations for personnel.

III. Forty-seven administrative, residential, industrial, strategic, and tactical military installations. Details, plans, and specifications show the design, construction, utilities, and camouflage. Geology was found to have a determining influence on the design and layout of the installations.



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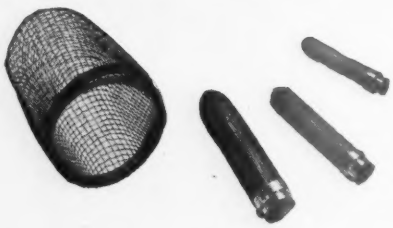

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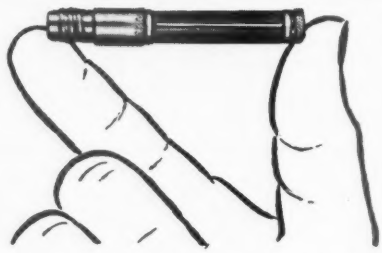

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Instruments

Investigation of the Fuselage Interference on a Pitot-Static Tube Extending Forward from the Nose of the Fuselage. William Letko. *U.S., N.A.C.A., Technical Note No. 1496*, December, 1947. 21 pp., illus. 4 references.

The interference effect of three fuselage nose shapes on a pitot-static tube extending various distances forward of the nose of the fuselage. The fuselages were bodies of revolution with maximum diameters equal to 12 per cent of the fuselage length; the nose shapes were circular, elliptical, and pointed. The tests were conducted for various angles of attack up to 30°. Theoretical estimates of the interference effect for zero angle of attack are included.

The Use of Air as a Volume-Measuring Fluid. Nathan Kaplan. *Instruments*, Vol. 20, No. 11, November, 1947, p. 1005, diagr.

In order to determine the free air volume inside an instrument without using a liquid, the instrument is evacuated to an arbitrary pressure. The volume of air required to raise again the pressure to atmospheric is used to compute the volume of the instrument.

Type 4713 Giannini Transducer. *G. M. Giannini and Co., Inc., Release*, Recd. December 29, 1947. 2 pp., illus.

The range of the pressure transducer is plus or minus 20 in. of water. It is $3^7/_8$ in. long, $1^7/_8$ in. in diameter and weighs less than six oz. The slack-diaphragm principle of measurement is used.

Corrections to a Mercurial Barometer and the Definition of a Barometric Unit. A. Kingsnorth. *The Technical Instructor*, Vol. 2, No. 10, October, 1947, pp. 6–9, diagrs.

An elementary explanation of the errors that arise in barometer readings and variations in the force of gravity, temperature, and altitude above or below mean sea level. A chart provides corrections for the reading of an altimeter that is calibrated either according to standard conditions or London Laboratory Conditions for a laboratory located at 51°45′ latitude and 450 ft. altitude. Includes definition of millibar and its conversion to other barometric units.

Influence of the Atmosphere Upon the Precision of Telescope Pointing. Francis E. Washer and Leo W. Scott. *U.S., National Bureau of Standards, Journal of Research*, Vol. 39, No. 4, October, 1947, pp. 297–302, figs. 3 references. Available also as *Research Paper No. RP1829*, U.S. Govt. Printing Office, Washington. $0.10.

The Sperry Pilot Aid; Introductory Details of a Simplified Autopilot for the Lighter Types of Aircraft. *Flight*, Vol. 52, No. 2027, October 30, 1947, pp. 489, 490, illus.

Description of the electric and pneumatic circuits of the Pilot Aid developed by the Sperry Gyroscope Co., Ltd. The unit weighs $17^1/_2$ lbs. and can control an aircraft weighing up to 15,000 lbs. The pilot is furnished control whereby he can apply banked turns within 20° limits of roll and climb and can dive within pitching limits of ± 10°. He may also alter course by caging and resetting the directional gyro.

The B-D Computer (Minneapolis-Honeywell). *Aero Digest*, Vol. 55, No. 6, December, 1947, pp. 49, 110, illus.

We Flew the Atlantic "No Hands." James M. Gillespie. *Popular Science Monthly*, Vol. 151, No. 6, December, 1947, pp. 97–101, illus. An account of the automatic-flight between Newfoundland and England made by the A.A.F. C-54, Robert E. Lee, in September, 1947.

Push-Button Pilot. Aubrey C. Cookman, Jr. *Popular Mechanics*, Vol. 88, No. 6, December, 1947, pp. 108–112, illus. (Cf. AER 12/47:41.)

Description of the functioning of the automatic flight controller during the transatlantic flight of the Robert E. Lee between Newfoundland and Brize Norton, England, in September, 1947.

Novel D-c. Selsyn Applications. R. L. Moeller. *Instruments*, Vol. 20, No. 10, October, 1947, pp. 920, 921, diagrs.

Description of 14 applications of the Selsyn remote indicator system which works off 12 or 24 volts d.c. The basic system, with slight modifications, provides indication of direction, degree of rotation, velocity, pressure, volume of liquid, and distance of travel.

Machine Elements

Developing the Epitrochoid Curve in Gear Teeth Below the Base Circle. H. C. Pepper. *Aircraft Engineering*, Vol. 19, No. 224, October, 1947, p. 320, fig.

Installation, Removal and Lubrication of Miniature Ball Bearings. *Landis & Gyr, Inc., Catalog No. 6, Supplement*, November, 1947. 8 pp., diagrs.

Research Into the Laws of Heat Dissipation in Journal Bearings. Ch. Hanocq. (*Revue Universelle des Mines*, Vol. 3, No. 7, 1947, pp. 245–258.) *Engineers' Digest*, Vol. 4, No. 11, November, 1947, pp. 530–537, illus.

Engineering Aspects of Bolt Variables. V. E. Hillman. *Iron Age*, Vol. 160, No. 21, November 20, 1947, pp. 62–68, diagrs.

Maintenance

Overhauling Jets for the Air Force. Mather M. Eakes, Jr. *Aero Digest*, Vol. 55, No. 6, December, 1947, pp. 54, 55, illus.

Aircraft Sheet Metal Structural Repair. I. Louie Boer. *Aviation Service Magazine*, November, 1947, pp. 20–22, 30, 31, 63, diagrs.

Refinishing Aircraft Fabric—Careful Application Required. *Canadian Aviation*, Vol. 20, No. 11, November, 1947, pp. 44, 46, 62, illus.

Working With the Transparent Acrylics. Gilbert C. Close. *Aviation Service Magazine*, December, 1947, pp. 14, 15, 38–40, 46, 66, illus.

Servicing Brakes in the Shops of Pan American Airways. Ed Packer. *Aviation Service Magazine*, November, 1947, pp. 12, 13, 46, illus.

Beechcraft Line Service Information (Models D18S and G17S). *Aviation Service Magazine*, November, 1947, pp. 28, 32, 42, 43, table.

Model 377 (Boeing Stratocruiser) Access Provisions. *Boeing Service Guide*, No. 2, November, 1947, pp. 7, 8, diagrs.

Replenishing the Model 377 (Boeing Stratocruiser) Airplane. *Boeing Service Guide*, No. 2, November, 1947, pp. 3–6, 9, diagrs.

Norfolk Speeds Up Fuselage Repair. *Naval Aviation News*, No. 8, December, 1947, p. 30, illus.

Outline of a system of fuselage repair in which a predetermined sequence of operations is broken down into five stages. The fuselage moves forward one stage at the beginning of each working day. The repair schedule for a TBM fuselage line is itemized.

BOAC Speedbirds Pay "On the Line." *Aircraft and Airport*, Vol. 9, No. 10, October, 1947, pp. 24, 25, 34, illus.

These Ideas Save Engine-Overhaul Time. D. R. Willard. *Air Transport*, Vol. 5, No. 11, November, 1947, pp. 64, 65, illus. Description of six power tools used in the engine-overhaul shop of Piedmont Aviation at Winston-Salem, N.C.

PAA Service in the Islands. Ed Packer. *Aviation Service Magazine*, December, 1947, pp. 16, 17, 34, 35, 48, 51, 55, illus.

Materials

METALS & ALLOYS

Development of Cast Aluminum Alloys for Elevated-Temperature Service. Webster Hodge, L. W. Eastwood, C. H. Lorig, and H. C. Cross. *U.S., N.A.C.A., Technical Note No. 1444*, January, 1948. 32 pp., figs.

Results of experiments to develop an aluminum alloy with a magnesium content of about 6 per cent which would have better tensile properties and better creep resistance at elevated temperatures than Y alloy and other commercial products. Twenty-three different metallic elements were added to the base alloy to determine the effect of the additives upon the room-temperature tensile properties, the tensile properties at 600°F., and the creep properties at the same temperature. An optimum composition was selected. Its characteristics are compared with Alcoa 142 (Y alloy) and Alcoa 254.

The Development of Ml Aluminum Alloy for Elevated Temperature Service. J. C. McGee. *U.S., Army Air Forces, Technical Report No. 5603*, June 25, 1947. 19 pp., illus. 12 references.

Data on physical properties, chemical composition, and microstructure were obtained from eleven aluminum alloys at room temperature and at 600°F. The ML aluminum alloy was developed on the basis of these data. Nominal composition is 4% Cu, 2% Mg, 2% Ni, 0.1% Ti, 0.3% Mn, 0.3% Cr, 0.03% Va, 0.3% Fe, and 0.3% Si. It has a hot tensile strength approximately 35 per cent higher than that of Y alloy. Each time the new alloy is melted for casting it must be kept at 1500°F. for 30 min. to ensure complete solution of all ingredients.

Reheating of 24S and 75S Aluminum Sheet. J. A. Nock, Jr. *Iron Age*, Vol. 160, No. 26, December 25, 1947, pp. 73–79, figs.

A study of the changes in tensile strength and corrosion resistance of alloys 24S and 75S, in both the naturally aged and the artificially aged state. Data on 24S in the temperature range 212° to 500°F. were studied. 75S was reheated within the limits 225° and 450°F. Although corrosion resistance was lowered, satisfactory mechanical properties were obtained with 24S as long as the reheating temperature did not exceed 250°F. No significant loss was noted in the mechanical properties of alloy 75S when reheated to 225°F., and the corrosion resistance was slightly improved.

Spot-Welded Aluminum Components Designed for Repeated Loads. Robert C. McMaster and Horace J. Grover. *Product Engineering*, Vol. 18, No. 12, December, 1947, pp. 158–161, illus.

The Production in Germany of Extruded Sections and Tubes in Aluminum and Magnesium Alloys. A. A. Reynolds, J. R. Cone, and others. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 1366, Item No. 21.* 128 pp., illus. British Information Service, New York. $3.50.

A comprehensive survey of processes, production methods, plant design, and methods of tooling, based on visits to 13 plants. A detailed description is given of the work in magnesium done by Wintershall A.G. at Herringen. The book, "Extrusion Presses and Their Working Tools," by Kurt Laue, is outlined. Dr. Laue was the chairman of the Standards Committee that was charged with rationalizing plant, tools, and tool steels for the extrusion and cold drawing of nonferrous materials. Chemical composition, aircraft specification number, name of the manufacturer, form, and mechanical properties of the principal aluminum and magnesium alloys that were produced during World War II are tabulated.

Activities of the Research Institute for Light Metals for Aviation, Tokyo. Sheldon W. Brown. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./82*, October 22, 1945. 7 pp., diagr. New York, British Information Services. $0.35. Outline of results of research on the extraction of alumina from the aluminous shale and clay by the soda-lime process.

Machining Cast Aluminum Alloys. J. J. Stobie, Jr. *Modern Metals*, Vol. 3, No. 10, November, 1947, pp. 16–23, figs. 48 references.

Carbides, Nitrides and Porosity in Aluminum. Davidlee von Ludwig. *The Iron Age*, Vol. 160, No. 21, November 20, 1947, pp. 73–78, 141, illus. 6 references.

High-Temperature Alloys; Metallurgical Problems of Gas Turbine Components. Sir William T. Griffiths. *Flight*, Vol. 52, No. 2027, October 30, 1947, p. 500, figs. (Extended abstract of a paper: "The Problem of High Temperature Alloys for Gas Turbines.")

Alloys for Gas Turbines. Sir William T. Griffiths. *Aircraft Production*, Vol. 9, No. 110, December, 1947, pp. 444–447, fig. 8 references.

Japanese Use of High Temperature Alloys in Rocket, Jet and Gas Turbine Applications. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./887*, 1947. 5 pp., tables. New York, British Information Services. $0.35.

Production methods, chemical composition, physical properties, and heat-treatment of nine steels developed for blades and combustion chambers of gas turbines and for the combustion chambers of rocket engines. Proof strength, creep limit, and fatigue limit data are given for temperatures between 500° and 700°C.

Creep and Some Creep-Resisting Alloys. G. Burns. *Engineering Materials*, Vol. 5, No. 19, October, 1947, pp. 123–126, fig.

A general summary of the phenomenon of creep and the application of creep data to the design of high temperature parts. General composition and characteristics of ferritic steels, austenitic steels, and nonferrous alloys.

The Production of High Speed and Other Special Alloy and Carbon Steels in Germany and Austria. E. Pasley, F. Henshaw, and others. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 1505, Item No. 21*, April, 1946. 157 pp., diagr. British Information Services, New York. $4.00.

Sixteen plants are reported. Composition of the steels is analyzed. Continuous casting processes were found to be impractical with the possible exception of the method of Heinz Puppe. High-temperature and turbine-blade steels produced by the Deutsche Edelstahlwerke, Fried Krupp A.G., and the Steirische Gusstahlwerke are analyzed.

How Low Temperature Treatments Affect Properties of Steel. H. W. Gillett. *Product Engineering*, Vol. 18, No. 12, December, 1947, pp. 81–84, illus.

The Effect of Length on the Strength of a Steel Wire. C. Gurney and S. Pearson. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2158*, November, 1945. 13 pp., illus. 7 references. British Information Services, New York. $1.00.

Electrodeposition of Tungsten Alloys Containing Iron, Nickel, and Cobalt. Abner Brenner, Polly Burkhead, and Emma Seegmiller. *U.S., National Bureau of Standards, Journal of Research*, Vol. 39, No. 4, October, 1947, pp. 351–383, illus. 27 references. Available also as *Research Paper No. RP1834*, U.S. Govt. Printing Office, Washington. $0.20.

Dislocation Theory of the Fatigue of Metals. E. S. Machlin. *U.S., N.A.C.A., Technical Note No. 1489*, January, 1948. 33 pp., illus. 26 references.

Dislocation theory of fatigue failure for annealed solid solutions, and equation giving dependence of number of cycles for failure on stress, temperature, material parameters, and frequency for uniformly stressed specimens. A predicted quantitative correlation between fatigue and creep is found to exist.

Ductility of Metals and Alloys Used in Construction; The Effects of Notching Under Axial and Eccentric Loads. G. Welter. (*Metallurgia* (London), Vol. 34, Nos. 203, 204, Vol. 35, No. 205, September, October, November, 1946, pp. 233–237; 304–310; 33–36.) *Engineers' Digest*, Vol. 4, No. 11, November, 1947, pp. 524, 525, figs.

Internal Stresses Arising From Transformations in Metals and Alloys. F. C. Thompson. *Engineering*, Vol. 164, No. 4269, November 21, 1947, p. 499. (Extended abstract of a paper.)

NONMETALLIC MATERIALS

A Survey of Plastic Materials; A Guide to Their Manufacture, Characteristics, Properties and Uses. I, II. G. Fitzgerald-Lee. *Aircraft Engineering*, Vol. 19, No. 223, September, 1947, pp. 291–293, 297, diagrs. Vinyl and thermosetting plastics.

Aircraft Veneer Plywood, Laminated Wood & Adhesives. G. F. Beardsley. *Gt. Brit., British Intelligence Objectives Sub-*

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Committee, Report No. B.I.O.S./J.A.P./P.R./110, November 3, 1945. 7 pp. British Information Services, New York. $0.35.

Brief summary of the standard veneer plywoods, hardened laminated woods, and adhesives used by the Japanese Navy. Vegetable and blood-protein adhesives had been developed for aircraft plywood. Sources of more detailed information on material specifications, physical properties, and design criteria are mentioned.

The Redux Bonding Process. K. S. Meakin. *The Technical Instructor*, Vol. 2, No. 10, October, 1947, pp. 10–17, illus. 8 references. Description of the use of a synthetic adhesive to obtain metal-to-metal, metal-to-wood, and metal-to-plastic bonds.

Industrial Adhesives. II. Nicholas J. de Lollis. *Product Engineering*, Vol. 18, No. 12, December, 1947, pp. 137–142, illus.

Properties and uses of thermosetting resin adhesives. Applications in wood, metal-to-wood, metal-to-metal, metal-to-glass, and plastic and rubber bonding.

Plastic Gears and Bearings. G. Fitzgerald-Lee. *Engineering Materials*, Vol. 5, No. 19, October, 1947, pp. 131–133, table.

SANDWICH MATERIALS

Compression Tests on Dural-Balsa Sandwich Panels. R. G. Chapman. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2153*, June, 1945. 21 pp., illus. 8 references. British Information Services, New York. $1.45.

Meteorology

Army Summer Atmosphere—Tables and Data. Robert M. Drake, Jr. *U.S., Army Air Forces, Technical Report No. 5540*, April 10, 1947. 6 pp. 4 references.

The tables give the variation of temperature and pressure with altitude from 4,000 ft. below sea level to an altitude of 46,500 ft. The temperature at sea level is assumed to be 100.4°F.

Météorologie et Vol à Voile (Meteorology and Gliding Flight). Alfred Urfer. *Schweizer Aero-Revue*, Vol. 22, No. 11, November, 1947, pp. 466–468, diagrs.

Dialing the Weather. Samuel Kramer. *Southern Flight*, Vol. 28, No. 5, November, 1947, pp. 18, 19, 48, diagrs. Suggestions for planning flights in thunderstorm and icing conditions.

Navigation

A Preliminary Study of a Physical Basis of Bird Navigation. Henry L. Yeagley. *Journal of Applied Physics*, Vol. 18, No. 12, December, 1947, pp. 1035–1063, diagrs. 37 references.

The ability of birds to navigate long distances without visual landmarks is attributed to a faculty that is sensitive to the effect of the birds' motion through the vertical component of the earth's magnetic field and to the effort that must be exerted to overcome the coriolis force caused by the rotation of the earth. These influences comprise the elements of a navigational gridwork. By correlating its instantaneous land speed with these two effects, the bird can fly to its home, which is a unique point in this gridwork, or to related companion points other than its home which also lie in this grid. In experimental flights, a magnetic field that moved up and down by the bird's wing motion was imposed upon homing pigeons. In another set of flights released in the vicinity of points which possessed the same magnetic characteristics as the birds' home, it was shown, as a first result, that pigeons are aware of their passage through the earth's magnetic field.

Operations

COMMERCIAL

The Air Cargo Potential. John H. Frederick. *Distribution Age*, Vol. 46, No. 11, November, 1947, pp. 34, 38, 59, illus.

Airfreight at Record Volume as Carriers Plan for 1948. Charles Adams. *Aviation Week*, Vol. 47, No. 52, December 22, 1947, pp. 36, 37, illus.

Needlework Along the Airways. James C. Nelson. *Air Transportation*, Vol. 11, No. 5, November, 1947, pp. 8, 10, 12–14, tables. A study of air shipments of needlework from Puerto Rico to the United States between January, 1945, and June, 1947. Statistics.

Le Développement du Fret Aérien National et International en France (The Development of National and International Air Freight in France). Charles d'Autrui. *Schweizer Aero-Revue*, Vol. 22, No. 11, November, 1947, pp. 476, 477.

Report from South Africa. Richard Kulze. *Air Transportation*, Vol. 11, No. 5, November, 1947, pp. 16, 17, 34, illus.

Authoritarian Spain Builds Air Services. *Air Transport*, Vol. 5, No. 11, November, 1947, pp. 49, 50, illus.

The Co-Ordination of Road, Rail and Air Services in Hyderabad State. E. W. Slaughter. *Institute of Transport, Journal*, Vol. 22, No. 15, October–November, 1947, pp. 554–558.

Ordnance & Armament

Japanese Optical Instruments Used in Connection With Fire Control Weapons. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R. 69, 70, 72, 73, 74, 77, 102*, December 12, 1945. 23 pp., illus. British Information Services, New York. $0.90.

Rolling Tester for Turrets. *The Martin Star*, December, 1947, pp. 12, 13, illus.

The Manufacture of Cast-Steel Bomb-Bodies. Percy H. Wilson. *Engineering*, Vol. 164, No. 4269, November 21, 1947, pp. 501–503, illus.

Parachutes

Il Paracadute a Velocità Variabile (The Lisi Variable-Velocity Parachute). I. Marazza. *Schweizer Aero-Revue*, Vol. 22, No. 10, October, 1947, p. 428.

Etwas über Fallschirme (Something About Parachutes). *Schweizer Aero-Revue*, Vol. 22, No. 11, November, 1947, pp. 477, 478, fig.

Personal Flying

The Stalemate in Private Flying. Kendall K. Hoyt. *Aero Digest*, Vol. 55, No. 6, December, 1947, p. 37, figs.

British Private Flying; Past, Present and Future. *The Aeroplane Spotter*, Vol. 8, No. 200, November 15, 1947, pp. 258–260, illus. Summary of the Preliminary Report of the Special Advisory Committee on Private Flying.

Photography

Five Million Pictures Per Second. *Instruments*, Vol. 20, No. 11, November, 1947, pp. 980, 982.

Description of a motion-picture camera developed at the University of Rochester by B. O'Brien and G. G. Milne. The camera is shutterless and employs a stationary optical system. The film is contained on the inside of a rotary drum and is driven at the rate of 400 ft. per sec.

Airmodels on Civvy Street. *Aircraft and Airport*, Vol. 9, No. 10, October, 1947, p. 28, illus. The construction of topographical models from aerial photographs.

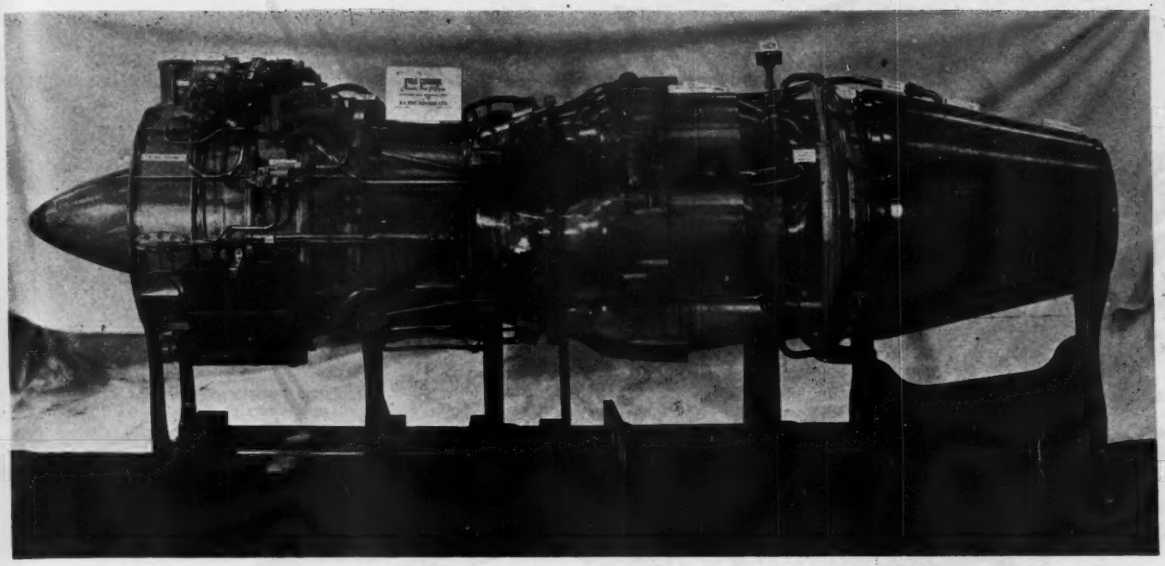
Power Plants

British Aero-Engine Survey. C. F. Caunter. *Aeronautics*, Vol. 17, No. 4, November, 1947, pp. 115–120, 123, 124, 127, 128, figs.

A comprehensive history of design progress from the beginning of World War II to date. Detailed specifications and performance figures are tabulated for 38 reciprocating engines and 21 gas turbines.

Comparison of Computed Performance of Composite Power Plants Using 18-Cylinder Aircraft Engines With 62° and 40° Valve Overlap. Samuel J. Kaufman and David S. Boman. *U.S., N.A.C.A., Technical Note No. 1500*, January, 1948. 27 pp., figs. 4 references.

The composite unit included, in addition to the engine, a steady-flow turbine and an auxiliary supercharger mounted on a common shaft and geared to the engine crankshaft. Calculations indicated that, in general, the system using the engine with 40° valve overlap was slightly more efficient and provided more power at optimum operating conditions than the system incorporating the engine with 62° valve overlap when fuel was introduced by means of a carburetor.



Mock-up of the Avro Chinook, first jet engine to be designed and built in Canada. The major components of the engine are a nine-stage axial-flow compressor, six through-flow combustion chambers, a single-stage axial-flow turbine, and an exhaust tail cone. The Chinook has a maximum outside diameter of 32 in., an overall length of 125 in., and a total weight of 1,250 lbs.

JET & TURBINE

A Method of Cycle Analysis for Aircraft Gas-Turbine Power Plants Driving Propellers. Robert E. English and Cavour H. Hauser. *U.S., N.A.C.A., Technical Note No. 1497*, January, 1948. 70 pp., diagrs. 18 references.

A theoretical analysis of the performance of a basic turbine-propeller engine and a basic engine modified by addition of intercooling, reheating, and regeneration, including effects of flight speed, jet thrust, altitude, and variations of working fluid. Charts were prepared to aid in computing compressor and turbine work and temperature change, engine performance, and gas states. The performances of four engines were compared. Reheating and intercooling increases the specific power output of the basic engine. In order to lower minimum specific fuel consumption, regenerator effectiveness must be more than 0.5.

English Translation of the Future of Gas Turbine Installations. R. Stroehlen. (*Allgemeine Elektrizitäts-Gesellschaft* and *Elektrotechnische Zeitschrift*, No. 7, 1941, p. 150 ff.) *U.S., Field Information Agency, Technical, Final Report No. 1034*, April 2, 1947. 89 pp., diagrs. British Information Services, New York. $2.75.

Contains translations of two papers and original German text: "High Pressure Gas Turbine Installations—A New Gas Turbine System Without Use of Heat Exchanger" and "The Stationary Gas Turbine, Its Thermal Efficiency and the Heating Surface of Its Heat Exchanger." The first paper consists of a description and a theoretical analysis of a gas turbine using a special type of two-stage compressor. In the first stage the compression is isothermal. In the second it is adiabatic. This results in a very high compression ratio and uses all the energy of compression to heat the working medium. The expansion, or work cycle of the engine, takes place at a high expansion ratio. Since the compression temperature is generally higher than the turbine exhaust temperature, the use of a heat exchanger is eliminated. The second paper provides comparative analysis of the efficiency of the Escher-Wyss Process; producer gas turbines; oil turbines, both with and without water cooling and with cooled compression; and steam power plants. The heat exchanger in the constant-pressure gas turbine is shown to be the determinant of the efficiency of the installation.

An Analysis of Jet-Propulsion Systems Making Direct Use of the Working Substance of a Thermodynamic Cycle. Kennedy F. Rubert. *U.S., N.A.C.A., Advance Confidential Report No. L5A30a (Wartime Report No. L-714)*, February, 1945. 81 pp., figs. 2 references.

Flight Tests of NACA Jet-Propulsion Exhaust Stacks on the Supermarine Spitfire Airplane. L. Richard Turner and Maurice D. White. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-680)*, December, 1942. 12 pp., illus. 1 reference.

Axial-Flow Compressors Are Simple. J. Austin King. *Aero Digest*, Vol. 55, No. 6, December, 1947, pp. 42–45, 105, 106, illus.

Altitude Blow-Out of Jet Engines Under Widespread Investigation. Robert McLarren. *Aviation Week*, Vol. 47, No. 21, November 24, 1947, pp. 22, 25, figs. 1 reference.

Gas Turbine Developments. C. B. Millikan. *Combined Intelligence Objectives Sub-Committee, Item No. 25, File No. 32-45*, July, 1945. 8 pp., diagrs. British Information Services, New York. $0.55.

Operating principles of the Schmidt water-cooled turbine blades. Water enters the hollow rotor shaft into ducts in the blade root, passes to the return duct at blade tip, and is conducted from the blade as steam through the exit end of the rotor shaft. The Ritz heat exchanger is also described, which was intended to make possible the use of a regenerative cycle in aircraft gas turbines.

Characteristics of Japanese Naval Vessels; Gas Turbines. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1150*, March, 1946. 19 pp., diagrs. New York, British Information Services. $0.90.

Report of unsatisfactory test runs on a 2,000-hp. turbine. Includes synopses of three papers on a gas-turbine combustion chamber, the basic phenomena of combustion, and refractory materials.

Canada's Jet Story. *Aircraft and Airport*, Vol. 9, No. 12, December, 1947, pp. 15–18, illus.

Summary of the factors that led to the foundation of Turbo Research Ltd. and the subsequent absorption of the organization by A. V. Roe Canada Ltd. The Chinook gas turbine, originally designed by Turbo Research, is being manufactured and developed by the new organization.

The BMW Jet Engine 109-003 A-1. Weirich. (January 25, 1945.) *U.S., Air Force, Translation No. F-TS-3052-RE*, January, 1948. 18 pp., illus.

Greater Turbojet Fuel Economy Object of New West Coast Design. *Aviation Week*, Vol. 47, No. 52, December 22, 1947, p. 22, fig.

Design description of the JHARL 6000XA turbojet engine under development by John Hawkins & Associates at North Hollywood, Calif. The peak combustion temperature is 1,300°F., the compression ratio is six to one, and the turbine inlet temperature is held to 1,250°F. at sea level.

The Story of the Nene. *American Rocket Society, Journal*, No. 71, September, 1947, pp. 12–16, table.

Unique (Westinghouse) Laboratory Speeds Jet Engine Development; Complete and Flexible Test Facilities for Turbojet

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GENERAL ELECTRIC turbosuperchargers—the "stilts" that per higher altitude flights—have received their first commercial appli tion on the Boeing Stratocruiser, latest in luxury airliners. This huge co mercial aircraft is to be used by several of the major airlines for high spe economical transcontinental and transoceanic flights. The use of the tur supercharger is expected to save up to 14 per cent in fuel consumption cruising altitudes, which will result in a substantial decrease in operati cost and an increase in the range of the plane.

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GENERAL ELECTRI

Components Are Valuable Guide for Future Designs. *Aviation Week*, Vol. 47, No. 22, December 1, 1947, pp. 30, 31, illus.

A Ram-Jet Engine for Fighters. E. Sänger and I. Bredt. (*ZWB, Deutsche Luftfahrtforschung, Untersuchungen und Mitteilungen/Nr. 3509*, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1106*, October, 1947. 80 pp., illus.

Simple and accurate calculations are made of the flow process in a continuous compressorless Lorin jet-propulsion unit. Experimental confirmation is given from towing tests on an airplane at flying speeds up to 200 meters per sec. The performance of a fighter airplane designed for utilization of this propulsion system is analyzed.

Project Squid Probes Pulsejet; Five Eastern Universities Hold Navy Research Contracts. Robert McLarren. *Aviation Week*, Vol. 52, No. 22, December 1, 1947, p. 26.

RECIPROCATING

Heat Flow Measurements. Ricardo and Co. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2171*, November, 1946. 15 pp., diagrs. 5 references. New York, British Information Services. $0.60.

Description of experiments to determine the local heat flow at different points in the cylinders of sleeve-valve aircraft engines. Data was obtained with a traversing thermocouple that slid in a small hole drilled in the cylinder wall. Heat flow was found to be mainly a function of output. There was little difference between the effect of increased speed and increased boost. Heat flow was affected differently at different points by this change, but since the differences followed no general rule, they might have been caused by local thermal distortions. Along the cylinder barrel there is remarkably little variation of heat flow. This is probably caused by "mechanical convection" by the moving sleeve. The sleeve-valve head was free from local concentrations around the valve seats. Except where the metal was exceptionally thick, most of the temperature difference between the bore and the water was a result of the drop at the water-metal boundary and not of the drop through the metal.

Release Process in a Four-Stroke Engine; Theory and Experiment Applied to an Aspect of the Silencing Problem. L. J. Kastner. *Aircraft Engineering*, Vol. 19, No. 224, October, 1947, pp. 323–327, figs. 2 references.

A method of establishing the noise spectrum of an aircraft engine. The pressure pulses in the exhaust pipe are analyzed and the form of the exhaust discharge pulse calculated on a basis of the conditions that obtain in the cylinder and exhaust pipe at the moment of discharge. Calculations based on the dimensions of an existing engine showed fair agreement with experimental data. The rate of rise in pressure during release, however, which was noted in the theoretical analysis and in actual measurements, indicates the basic correctness of the method.

Effect of Various Factors on Heat-Flow in Four-Cycle Petrol Engines. H. R. Ricardo. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2172*, November, 1946. 5 pp., tables. British Information Services, New York. $0.55.

Discussion of the effect on the heat flow to the cylinder wall of both poppet and sleeve-valve engines of: mixture strength, air swirl, ignition timing, throttling and boosting, induction temperature, compression ratio, valve timing, and injection of mixtures of water and fuels of high latent heat.

Effect of Changing Manifold Pressure, Exhaust Pressure, and Valve Timing on the Air Capacity and Output of a Four-Stroke Engine Operated with Inlet Valves of Various Diameters and Lifts. James C. Livengood and James V. D. Eppes. *U.S., N.A.C.A., Technical Note No. 1366*, December, 1947. 64 pp., diagrs. 7 references.

Cooling in Cruising Flight With Low Fuel-Air Ratios. Abe Silverstein and Herbert A. Wilson, Jr. *U.S., N.A.C.A., Memorandum Report (Wartime Report No. L-570)*, June, 1942. 9 pp., illus. 3 references.

Review of Flight Tests of NACA C and D Cowlings on the XP-42 Airplane. J. Ford Johnston. *U.S., N.A.C.A., Report No. 771*, 1943. 10 pp., illus. 11 references. U.S. Govt. Printing Office, Washington. $0.15.

It's "Waste Makes Haste" in Exhaust Gas Story. William P. Botherton. *Aircraft and Airport*, Vol. 9, No. 12, December, 1947, pp. 28, 30, 39, illus.

Aircraft Oil Coolers—Their Design, Testing and Maintenance. D. W. Richardson. *The Technical Instructor*, Vol. 2, No. 10, October, 1947, pp. 1–5.

Bayerische Motoren Werke (B.M.W.), Oberwiesenfeld, Munich, and at Allach, Near Munich. F. G. Barlow, P. W. Smith, and others. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 141, Item No. 26*, July 14, 1947. 6 pp., illus. British Information Services, New York. $0.55.

A superficial investigation to discover the lines of development followed by B.M.W. on reciprocating aircraft engines and to compare inspection procedure with British practice.

Inert Gas Protects Gasoline. *Naval Aviation News*, No. 8, December, 1947, p. 29.

Details of the fire-prevention system installed in a PB4Y-2 for developmental purposes. Cooled exhaust gas from the engine is conducted into and around the fuel cells in the aircraft wing. The inert atmosphere thus provided contains less than 2 per cent oxygen.

Metallurgical Examination of Japanese Kasei-21 Aircraft Engine No. 2189. L. H. Grenell, A. B. Westerman, and others. *Gt. Brit., British Intelligence Objectives Sub-Committee, Report No. B.I.O.S./J.A.P./P.R./1507*, August 27, 1945. 36 pp., illus. British Information Services, New York. $1.30.

C.A.V.-Ricardo Pintaux Nozzle. (*Gas and Oil Power*, Vol. 42, No. 504, September, 1947, pp. 279–281.) *Engineers' Digest*, Vol. 4, No. 11, November, 1947, pp. 509, 510, diagrs.

Stratocruiser (Boeing 377) Power Package Description. *Boeing Service Guide*, No. 3, December, 1947, pp. 2–12, illus. Detailed description and labelled illustrations of the four 3,500-hp. Pratt & Whitney Wasp Major engines and accessories.

Rolls-Royce Eagle Engine May Be Last of Piston Type. *Aircraft and Airport*, Vol. 9, No. 11, November, 1947, pp. 30, 32, 47, illus.

ROCKET

Introduction to the Problem of Rocket-Powered Aircraft Performance. H. Reese Ivey, Edward N. Bowen, Jr., and Lester F. Oberny. *U.S., N.A.C.A., Technical Note No. 1401*, December, 1947. 46 pp., diagrs. 1 reference.

A detailed and comprehensive exposition of the mechanics of rocket propulsion. The material summarizes existing literature from both published and confidential sources on: the limiting velocity of a rocket projectile, the limiting velocity of a rocket jet, jet efficiency, nozzle characteristics, maximum attainable altitudes, and range. The first half of the paper presents the subject nonmathematically. The second half gives the mathematical derivations, the assumptions, and the formulas used in the analysis. The calculations are illustrated throughout by working out simple applications of the formulas to a rocket missile.

The Absorption-Emission Pyrometer: A New Method for Measuring Flame Temperatures. *Instruments*, Vol. 20, No. 11, November, 1947, pp. 978, 980, illus. Developed by D. H. Jacobs of North American Aviation, Inc., for recording rocket exhaust-flame temperatures up to 4,000°F.

Guided Missile Rocket Power Plant Design and Installation Problems. Alfred K. Huse. *American Rocket Society, Journal*, No. 71, September, 1947, pp. 16–21.

The Rocket Research of Dr. Robert H. Goddard. Alfred Africano. *American Rocket Society, Journal*, No. 71, September, 1947, pp. 28–45, figs. 13 references.

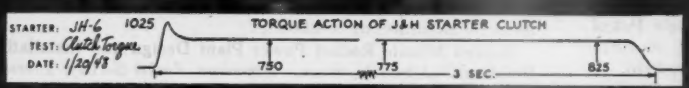
A brief summary of the research of Dr. Goddard and a detailed explanation of his minimum mass equation for rocket motion. The formula is used to compute tables showing the mass ratio required for a rocket to reach various maximum altitudes and similar data and surface ranges for six-step rockets. The theoretical performance of the V-2 is calculated, and it shows an agreement within from 1 to 3 per cent upon comparison with the actual flight data that was obtained in firing tests. An appendix gives the variation in pressure and density of the atmosphere with altitude from sea level to 100,000 ft. and a condensed table of the Gavre retardation function *G*. Sixty-nine patents issued to Dr. Goddard between 1914 and 1946 are listed.

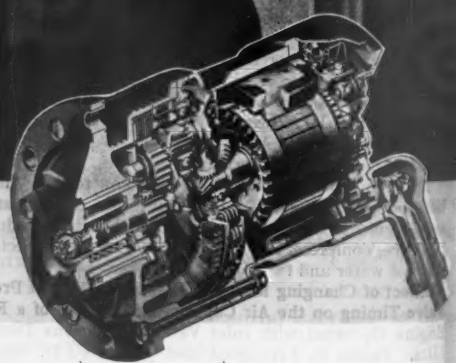
Production

Machining Turbine Blades. II—Blade Analysis: Work Holding: Cam Development. T. A. Kestell. *Aircraft Production*, Vol. 9, No. 110, December, 1947, pp. 460–465, illus. (Cf. AER 2/48:59.)

Standardized Fixtures for Machine Work. *Aircraft Engineering*, Vol. 19, No. 224, October, 1947, pp. 334, 335, illus.

Deep-freeze sweat box





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The Bristol "Brabazon" Aircraft. *Engineering*, Vol. 164, No. 4264, October 17, 1947, pp. 369, 370, illus.

Brabazon Bearing Brackets; Small-Quantity Manufacture of Large Forgings for the Prototype Bristol 167 Aircraft. *Aircraft Production*, Vol. 9, No. 110, December, 1947, pp. 457–458, illus. 1 reference.

Blackburn Cirrus; Production of Series II and III Engines: Design Features: Machining the Crankcase, Cylinder Head and Connecting Rods. J. A. Oates. *Aircraft Production*, Vol. 9, No. 110, December, 1947, pp. 449–456, illus.

Magnesium-Alloy Doors; Production of Large Castings for Avro Tudor Aircraft. R. W. Eade. *Aircraft Production*, Vol. 9, No. 110, December, 1947, pp. 466–469, illus.

Welding in the U.S. Aircraft Industry; A French Production Engineer's Views on the Position of Welding in America. I. R. Grimaud. *Aircraft Engineering*, Vol. 19, No. 224, October, 1947, pp. 331–333, tables.

Survey of American spot-welding practice, including details of the machines in use and detailed specifications for degreasing, etching, and inspection of the work pieces.

Mechanized Inert-Gas-Shielded Arc Welding. H. T. Herbst. *Modern Metals*, Vol. 3, No. 10, November, 1947, pp. 28–32, illus.

Riveting Skin Joints; Some Problems Encountered in Large Aircraft. Henry Krowler. *Aircraft Production*, Vol. 9, No. 110, December, 1947, p. 443, diagrs. (Extended abstract of a paper.)

Propellers

Whirl Test of the Camfield Model NC15 Test Club for Use With the R-4360 Engine. E. J. Thomas. (*Whirl Test No. 2159.*) *U.S., Army Air Forces, Technical Report No. 5574*, April 18, 1947. 17 pp., illus.

Wind-Tunnel Tests of Two Hamilton Standard Propellers Embodying Clark Y and NACA 16-Series Blade Sections. W. H. Gray. *U.S., N.A.C.A., Memorandum Report* (*Wartime Report No. L-530*), August, 1941. 30 pp., illus. 2 references.

Calibration of a 2-Blade, Adjustable Pitch Hamilton Standard Propeller, 9 Ft. Diameter, Blade Design No. 0166637 and Hub Design No. 31-1775, for Use as a Test Club on Engines Ranging in Power From 100 to 225 Hp. Frederick Lang. (*Whirl Test No. 1499.*) *U.S. Army, Air Corps, Technical Report No. 4638*, May 10, 1941. 11 pp., figs.

Electric Motor and Water Spray Test of a Hoover Hydraulic Propeller, Hub No. H2M007, Incorporating Singer Manufacturing Company Blades, Design No. 3098-A. James B. Sibert and E. J. Hale. (*Whirl Test No. 1717.*) *U.S., Army Air Forces, Technical Report No. 4974*, July 21, 1947. 58 pp., illus.

Type Test of Modified North American Aviation Spinner No. 104-44002 for Hamilton Standard Propellers on P-51B Aircraft. E. L. Haley. (*Whirl Test No. 2034.*) *U.S., Army Air Forces, Technical Report No. 5592*, June 13, 1947. 4 pp., illus.

Electric Motor Tests of the 40 and 60 Shaft Units of the Wickwire Spencer Dual Rotation Propeller. E. A. Wonderheid. (*Whirl Test No. 1932.*) *U.S., Army Air Forces, Technical Report No. 5546*, February 10, 1947. 13 pp., illus.

Rotating Wing Aircraft

Helicopters by Night; A Canvass of the Industry Brings Vital Information on Special Advantages of 'Copter Flying After Dark. Alexander Klemin. *Aero Digest*, Vol. 55, No. 6, December, 1947, pp. 51, 112–115, 117, 118, illus.

Engine-Off Landings. *Flight*, Vol. 52, No. 2029, November 13, 1947, pp. 546–548, diagrs. (Extended abstract of a paper: "Some Work With Rotating-Wing Aircraft," O. L. L. Fitzwilliams.)

Helicopters for Mails; Experimental Work by B.E.A. *Modern Transport*, Vol. 58, No. 1495, November 22, 1947, p. 7, illus.

All-Weather Helicopter Blades of Stainless Steel. *Goodyear Tire and Rubber Co., Release*, Recd. December 20, 1947. 2 pp.

Description of the stainless-steel sandwich construction helicopter blades built by the Goodyear Aircraft Corporation. The blades have lifting characteristics superior to conventional blades, incorporate a leading edge deicing system, and may be flown safely in light or heavy rain.

Bell, Sikorsky Explore Market with New Two-Place Helicopters (47D and S-52). *Aviation Week*, Vol. 47, No. 52, December 22, 1947, p. 17, illus.

Die Vorführung des Bell-Helicopters 47B (Demonstration of the Bell 47B Helicopter on October 13 at Wollishofer Allmend, Zurich). *Schweizer Aero-Revue*, Vol. 22, No. 11, November, 1947, pp. 455–458, 461, illus.

Wie Wird der Bell-Helicopter Geflogen? (How is the Bell Helicopter Flown?) *Schweizer Aero-Revue*, Vol. 22, No. 11, November, 1947, pp. 458, 459, diagrs.

Bristol (171) Helicopter. *Flight*, Vol. 52, No. 2027, October 30, 1947, pp. 494a–d, 495, 496, cutaway diagrs.

Helicopters in Britain; The Bristol 171; Notable Safety Features Incorporated. *Modern Transport*, Vol. 58, No. 1494, November 15, 1947, pp. 7, 8, illus.

German Submarine Rotary Wing Kite (Focke-Achgelis Fa 330). Bartram Kelley and Hugh J. Mulvey. *Combined Intelligence Objectives Sub-Committee, Item No. 12, File No. 28–21.* 25 pp.; illus. British Information Services, New York. $0.90.

Automatic Feathering (Kaman K-125-A Helicopter). *Aero Digest*, Vol. 55, No. 6, December, 1947, p. 53, diagrs.

Kellett XR-10 Performance. *Aero Digest*, Vol. 55, No. 6, December, 1947, pp. 52, 53, illus.

Twin Rotors Counteract Torque Reaction. (Kellett XR-10). *Product Engineering*, Vol. 18, No. 12, December, 1947, pp. 88–91, illus.

M.A.C. Flies World's First Ram-Jet Helicopter; Experimental "Flying Test Stand" Built for Air Force, Lifts Its Own Weight, Has Flown Up to Fifty MPH. *McDonnell Airscoop*, Vol. 6, No. 29, December, 1947, p. 2, illus.

McDonnell Flies Ramjet Helicopter; Experimental Craft Built for Air Force Lifts Own Weight; Has Hit 50 Mph. Robert McLarren. *Aviation Week*, Vol. 47, No. 21, November 24, 1947, p. 14, illus.

Safety & Rescue

Engineering for Safety. William I. Stieglitz. *Aeronautical Engineering Review*, Vol. 7, No. 2, February, 1947, pp. 18–23.

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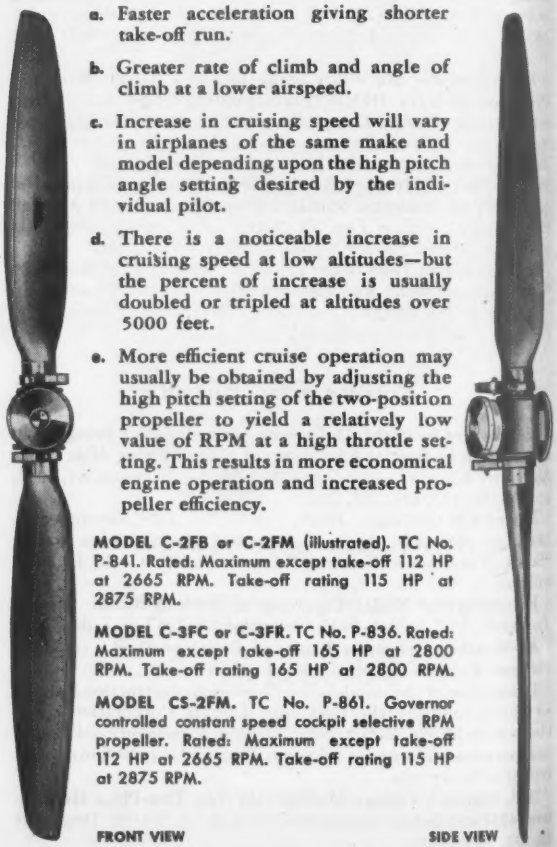

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Methyl Bromide as Fire Extinguisher. Scholar Bangs. *Aviation Week*, Vol. 47, No. 22, December 1, 1947, p. 28.

Crash! Fire! *Naval Aviation News*, No. 8, December, 1947, p. 23, illus. Description of Navy fire fighting equipment and crash trucks at air installations, on carriers, in dirigible hangars, and at piers.

Emergency Exits and Equipment (Boeing 377 Stratocruiser). *Boeing Service Guide*, No. 3, December, 1947, pp. 13–15, diagrs.

Inflatable Exposure Suit; Features of British "Quilted" Design. *Flight*, Vol. 52, No. 2029, November 13, 1947, p. 561, illus.

Sciences, General

DYNAMICS

Gyroscopic Effects in a Vibratory System. G. S. Bennett. *Journal of Applied Physics*, Vol. 18, No. 12, December, 1947, pp. 1110–1112, diagrs. 1 reference.

An analytical investigation to determine whether gyroscopic effects caused by rotating elements of aircraft equipment exert any marked influence on the vibration characteristics of the equipment. The equations derived show that if precession be prevented, no gyroscopic effects are present and that if precession be permitted, the gyroscopic action contributes a force opposed to the tilt and proportional to the angle of tilt. This latter effect is the equivalent of increasing the stiffness of the elastic system. Calculations based on an arbitrarily chosen rotor, which approximates a typical small motor armature, indicate that this additive spring force is small and that the increase in natural frequency it causes is in the order of 0.1 per cent when the precessional motion is not restrained.

MATHEMATICS

Vibrational Problems in Elliptical Coordinates. N. W. McLachlan. *Quarterly of Applied Mathematics*, Vol. 5, No. 3, October, 1947, pp. 289–297. 7 references.

Recently published lists of solutions of the ordinary and the modified Mathieu equations and the corresponding equations for $q>0$ are used to derive formal solutions for the vibrational modes of: a uniform, homogeneous, loss-free stretched membrane in the form of an elliptical ring; water in a lake of uniform depth whose plan view is an elliptical ring; a uniform, homogeneous, loss-free, elastic elliptical plate; and a uniform, homogeneous, loss-free, elastic elliptical ring plate. As the outer bounding ellipse tends to a circle, the formulas degenerate to those already known for these cases when the boundary is circular.

Schwarz' Inequality and the Methods of Rayleigh-Ritz and Trefftz. J. B. Diaz and Alexander Weinstein. *Journal of Mathematics and Physics*, Vol. 26, No. 3, October, 1947, pp. 133–136.

In the case of quadratic functionals, a simple and direct application of Schwarz's inequality and Green's formula can be used to derive both the Rayleigh-Ritz method and Trefftz's procedure. This approach is shorter and more elementary than the analysis of Friedrichs's which showed the connection of Trefftz's method with Legendre's transformation.

The Accuracy of the Root-Squaring Method for Solving Equations. P. G. Hoel and D. D. Wall. *Journal of Mathematics and Physics*, Vol. 26, No. 3, October, 1947, pp. 156–164.

An investigation of the errors that are introduced by not raising the original equation to a sufficiently high power and those rounding errors that are introduced by the limited capacity of the calculating machine. The bounds for these two kinds of errors are obtained.

Tables for Facilitating the Use of Chebyshev's Quadrature Formula. Herbert E. Salzer. *Journal of Mathematics and Physics*, Vol. 26, No. 3, October, 1947, pp. 191–194, tables.

Numerical Methods for Finding Characteristic Roots and Vectors of Matrices. W. M. Kincaid. *Quarterly of Applied Mathematics*, Vol. 5, No. 3, October, 1947, pp. 320–345. 7 references.

Variants of the iteration process are used to find the largest characteristic root and corresponding vector and other roots and vectors of a matrix that has linear elementary divisors. The methods are extended to the case of complex roots and the solution of algebraic equations by the use of matrices. Emphasis is placed on the numerical solution of practical problems.

A Generalization of the Finite Fourier Transformation and Applications. Ida Roettinger. *Quarterly of Applied Mathematics*, Vol. 5, No. 3, October, 1947, pp. 298–319. 19 references.

A direct, short, and systematic approach by which problems in partial differential equations may be solved directly, when by a suitable change of variables they can be brought into a form in which variables can be separated. Tables of transforms, which, except for formalization factors, are tables of generalized Fourier coefficients, save time in the computation of solution of practical problems. Certain theorems give this operational method the advantage of systematically finding closed form solutions. Thus qualitative properties of a solution are exhibited which may not readily be found by the usual methods.

An A.C. Network Analyser. *The Engineer*, Vol. 184, No. 4789, November 7, 1947, pp. 442–444, illus.

A detailed description of the equipment, layout, and operation of the Associated Electrical Industries, Ltd., a.c. network analyzer. The installation at the British Thomson Houston Company's Willesden works is available for the study of a.c. systems; stability problems, including steady-state limits and transient limits; and mechanical, thermal, and hydraulic problems that can be represented by electrical equivalents.

Bessel Functions in Physics: Applications. II. T. A. Benham. *Journal of American Physics*, Vol. 15, No. 6, November–December, 1947, pp. 488–497, diagrs. 9 references.

For solving problems of the vibrating drumhead, the acoustic horn, waves in a liquid, the triode vacuum tube, frequency modulation, and electromagnetic waves in cylindrical pipes.

MECHANICS

Friction at High Sliding Velocities. Robert L. Johnson, Max A. Swikert, and Edmond E. Bisson. *U.S., N.A.C.A., Technical Note No. 1442*, October, 1947. 35 pp., illus. 18 references.

Reports experiments conducted with kinetic-friction apparatus with steel specimens over ranges of speeds between 50 and 6,600 ft. per min. and loads from 169 to 2,232 Gm. Kinetic friction decreases with sliding speed for dry and for some boundary-lubricated surfaces at high sliding speeds. Amonton's law was verified at all speeds with dry and boundary-lubricated surfaces. Changes in the physical characteristics of material resulting from high surface temperatures caused by increased rate of surface stressing and occurrence of ferrous oxide on the sliding surface are possible causes for reduction in kinetic friction with high sliding velocities.

Dry Friction of Metals as Affected by Surface Finish and Surface Coatings. (*Die Technik* (Berlin), Vol. 2, No. 4, April, 1947, pp. 166–170.) *Engineers' Digest*, Vol. 4, No. 11, November, 1947, pp. 516, 517, diagrs.

Seaplanes & Flying Boats

A Graphical Method for Interpolation of Hydrodynamic Characteristics of Specific Flying Boats From Collapsed Results of General Tests of Flying-Boat-Hull Models. F. W. S. Locke, Jr. *U.S., N.A.C.A., Technical Note No. 1259*, January, 1948. 34 pp., figs. 11 references.

The method is graphical and will allow interpolation of the hydrodynamic characteristics for any combination of load or

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aerodynamic characteristics. To obtain the water resistance and porpoising characteristics of one specific case requires about 20 or 30 minutes' work. It is believed that the rapidity with which interpolations may be made will open up the way for comprehensive design studies of the influence of various factors on flying-boat performance.

The NACA Impact Basin and Water Landing Tests of a Float Model at Various Velocities and Weights. Sidney A. Batterson. *U.S., N.A.C.A., Report No. 795*, 1944. 7 pp., illus. U.S. Govt. Printing Office, Washington. $0.15.

Following a description of the N.A.C.A. impact basin and its equipment, a relationship is derived between resultant velocity and impact normal acceleration for various float weights when all other parameters are constant. The maximum impact normal acceleration is found to be proportional to the square of the resultant velocity. Increases in float weight resulted in decreases in maximum impact normal acceleration and an increase in the flight-path angle caused increased impact normal acceleration.

Spray Characteristics of a Powered Dynamic Model of a Flying Boat Having a Hull With a Length-Beam Ratio of 9.0. Roland E. Olson and Joe W. Bell. *U.S., N.A.C.A., Advance Restricted Report No. L5L29* (*Wartime Report No. L-763*), January, 1946. 30 pp., illus. 8 references.

Investigation of the Effect of Spray Strips on the Low-Speed Spray Characteristics of a 1/8-Size Model of the Consolidated PB2Y-3 Flying Boat—NACA Model 116E-3. Roland E. Olson. *U.S., N.A.C.A., Memorandum Report* (*Wartime Report No. L-616*), January, 1943. 25 pp., illus. 3 references.

Tank Tests of a 1/8-Size Dynamic Model of the PBY2-3 Airplane With Increased Power—NACA Model 131. Joe W. Bell and Robert F. Havens. *U.S., N.A.C.A., Memorandum Report* (*Wartime Report No. L-688*), June, 1943. 41 pp., diagrs. 4 references.

Aerodynamic and Hydrodynamic Tests of a Family of Models of Flying-Boat Hulls Derived from a Streamline Body NACA Model 84 Series. John B. Parkinson, Roland E. Olson, Eugene C. Draley, and Arvo A. Luoma. *U.S., N.A.C.A., Report No. 766*, 1943. 89 pp., illus. 20 references. U.S. Govt. Printing Office, Washington. $0.45.

Facts for Float Fliers. *Aircraft and Airport*, Vol. 9, No. 10, October, 1947, pp. 22, 50, 51. Tips for removal and inspection of floats for storage.

Stress Analysis & Structures

Distribution of Stress Between Spar Flanges and Stringers for a Wing Under Distributed Loading. D. Williams, R. D. Starkey, and R. H. Taylor. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2098*, June, 1939. 47 pp., diagrs. 13 references.

The "Minimum Potential Energy" principle is used to obtain a solution of the problem of the stress distribution in the stringer-reinforced cover of a box beam. The solution takes account of an arbitrary load distribution at the spar flanges as well as of an arbitrary variation of the cross-section area of the flanges. Any number of stringers can be dealt with as long as they are of equal and uniform cross section; otherwise only a restricted number can be treated without excessive numerical work. When the load is uniformly distributed there is one section at which the direct stress is practically the same for stringers and flanges. Between this section and the free end the stringer stresses are higher than those in the flange while in the rest of the span the reverse is the case. If the spar flanges are tapered to suit the load distribution, the variation of direct stress across the sheet is much reduced and throughout spar flanges and stringers tends to approximate that given by ordinary engineering theory. A thick sheet with small-size stringers tends to produce a distribution of stress in agreement with the simple engineering theory.

The Elasto-Plastic Stability of Plates. A. A. Iliushin. (*Prikladnaia Matematika i Mekhanika* (Moscow), Vol. 10, No. 5-6, 1946, pp. 623-638.) *U.S., N.A.C.A., Technical Memorandum No. 1188*, December, 1947. 30 pp., diagrs. 2 references.

An improvement is made in the author's derivation of the relations between the stress factors and the strains that result from the instability of plates and shells. In the strict analysis the problem reduces to the solution of two fourth order simultaneous nonlinear partial differential equations in the deflections and stress function. The approximate analysis, on the other hand, reduces to a single linear equation of the Bryan type. The accuracy

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obtained by the approximate method is shown to be satisfactory by the solutions that are given for the special case of a rectangular plate buckling into a cylindrical form and the case of an arbitrarily shaped plate under uniform compression.

Instability of Outstanding Flanges Simply Supported at One Edge and Reinforced by Bulbs at Other Edge. Stanley Goodman and Evelyn Boyd. *U.S., N.A.C.A., Technical Note No. 1433,* December, 1947. 25 pp., diagrs. 7 references.

The compressive buckling stress of outstanding flanges reinforced by bulbs was determined by the torsion-bending theory for flanges having 54 shapes and a range of lengths. The edge of the flange opposite the bulb and the loaded ends were considered simply supported. The results were analyzed to determine the shape of flanges that gave the greatest support to the structure to which it was attached. The flanges capable of giving the most support without torsional buckling had overall flange widths from $1.9\sqrt{A_F}$ to $2.6\sqrt{A_F}$, where A_F is the cross-sectional area of the flange.

An Improved Photoelastic Method for Determining Plane Stresses. C. B. Norris and A. W. Voss. *U.S., N.A.C.A., Technical Note No. 1410,* January, 1948. 43 pp., illus. 8 references.

An improved photoelastic method has been developed for determining stress concentrations that occur in nonisotropic materials under load. Drucker's method has been extended by means of an additional oblique photograph, and simpler equations for relating fringe order to principal stresses were obtained. The present method is considered more accurate than Drucker's and also provides a means of determining the directions of the principal stresses. The determination of these directions, however, is not sufficiently accurate, and the use of a stress coat was found desirable for greater accuracy.

Flutter at High Incidence. Mary Victory. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2048,* January, 1943. 27 pp., figs. 15 references. British Information Services, New York. $1.60.

An investigation to determine whether the flexure-torsion flutter speed of a wing is less at high incidences than at low incidences. The flutter speed was found to decrease at high incidences, principally because of the aerodynamic torsional damping. The aerodynamic torsional damping was found to vary also with the frequency parameter and the position of the flexural axis. When the parameter is greater than 1.0 the variation of the damping coefficient with incidence is reduced so that it does not fall below 60 per cent of its value at zero incidence. The variation of the damping coefficient is further reduced if the flexural axis is moved toward the quarter-chord position. The drop in flexure-torsion wing flutter speed of a modern aircraft will be small at high incidences because for modern monoplanes the values of the frequency parameter that would be obtained at low incidences are usually greater than 1.5. Further, the flexural axes of most modern aircraft are well forward.

Approximations in Elasticity Based on the Concept of Function Space. W. Prager and J. L. Synge. *Quarterly of Applied Mathematics,* Vol. 5, No. 5, No. 3, October, 1947, pp. 241–269, figs. 4 references.

A method of obtaining approximate solutions of elastic boundary value problems with calculable errors. The error is measured in terms of distance in function space, or, equivalently, in terms of strain energy. The theory developed applies to any elastic body possessing a positive definite strain energy function, quadratic in the components of stress. The point or vector in a function space which is determined by this function represents a state of stress. Since the geometry of function space follows closely Euclidean analogies, the solution of an elastic boundary-value problem is considered as a point in function space located on a hypercircle of determinable center and radius. As a practical test, the method is used to obtain approximate solutions for the torsion of a prism of square cross section.

Structural Work at Focke-Wulf, Bad Eilson. D. C. Appleyard. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 285, Item No. 25.* 12 pp., diagrs. British Information Services, New York. $0.55.

Brief report of experimental and developmental work on: testing of structures under repeated loading, stressed skin structures, photoelasticity, construction methods, the use of high-tensile steel, spot welding, and the use of wood and plastics in aircraft.

"Bear-Up" Requirements for Aircraft. Bo Lundberg. *Aero Digest,* Vol. 55, No. 6, December, 1947, pp. 56–58, 120–122, figs. (From: "Note on Fatigue Strength Requirements for Aircraft." Montreal, Provisional International Civil Aviation Organization, Airworthiness Division, Second Session, Document No. 2936 AIR-147, March 13, 1947.) (Cf. AER 9/47:83.)

The Distribution of Shear in a Tapered Fuselage—Strain Measurements on Barracuda V. D. C. Allen. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2163,* April, 1945. 15 pp., diagrs. 3 references. British Information Services, New York. $1.00.

Determination of Gross Weight. W. Nichols. *Aero Digest,* Vol. 55, No. 6, December, 1947, pp. 66–68, 107, figs.

A formula is proposed which relates the empty weight, rated horsepower, and maximum speed of an aircraft. A correction factor that is unique for the type of aircraft under consideration is introduced to accommodate the inherent weight characteristics. The formula is used to calculate the weight of 19 British and American airplanes. In most cases the calculations agree with the known gross weight within 3 per cent.

The Calculation of Aileron Reversal Speed. Mary Victory. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2059,* January, 1944. 15 pp., figs. 14 references. British Information Services, New York. $1.00.

A review of current British methods, with discussion of the values of the aerodynamic coefficients, the dimensions and stiffnesses, and the compressibility corrections.

A Direct Reading Electrical Strain Meter. F. C. Widdis. *Journal of Scientific Instruments,* Vol. 24, No. 11, November, 1947, pp. 302, 303, illus.

Thermodynamics

High Speed Schlieren Camera for Observation of Flame Travel. G. B. E. Feilden. *Gt. Brit., British Intelligence Objectives Sub-Committee, Final Report No. 14, Item No. 9,* July 14, 1947. 8 pp., diagrs. British Information Services, New York. $0.55.

Design of a high-speed camera that has operated at speeds up to 25,000 pictures per sec. with an exposure duration of about 1 microsecond. Intermittent spark illumination is used in conjunction with a simple rotating drum camera.

History and Exposition of the Laws of Thermodynamics. Joseph H. Keenan and Ascher H. Shapiro. *Mechanical Engineering,* Vol. 69, No. 11, November, 1947, pp. 915–921. 14 references.

A summary of the expositions of the first law of thermodynamics given by Poincaré and by Caratheodory. A comparison of the two methods of exposition and their two extensions shows the development of clarity in definition, rigor in logical developments, and the present more accurate interpretation of fundamental data.

Expansion Time Rate of Gases. W. D. Munroe. *American Rocket Society, Journal,* No. 71, September, 1947, pp. 8–11, figs.

Wind Tunnels & Laboratories

Notes on the N.P.L. 13 Ft. × 9 Ft. and 9 Ft. × 7 Ft. Wind Tunnels. E. J. Richards and F. Cheers. *Gt. Brit., Aeronautical Research Council, Reports and Memoranda No. 2136,* July, 1945. 15 pp., diagrs. 3 references. British Information Services, New York. $1.15.

Description of the main features of the four atmospheric single-return closed-jet wind tunnels of the National Physical Laboratory. Power and turbulence factors, pressure gradient, wind-tunnel interference, and starting and stopping characteristics are described for all four tunnels. Calibration of the flow direction and velocity is given for the 9 ft by 7 ft. tunnels. Maximum wind speed is 250 ft. per sec. in the large tunnels and 230 ft. per sec. in the smaller tunnels.

Jet-Boundary Corrections to the Downwash Behind Powered Models in Rectangular Wind Tunnels With Numerical Values for 7- by 10-Foot Closed Wind Tunnels. Robert S. Swanson and Marvin J. Schuldenfrei. *U.S., N.A.C.A., Advance Restricted Report (Wartime Report No. L-711),* August, 1942. 33 pp., figs.

(Continued on page 90)

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This Sperry pilot is on an important flight mission. In one of Sperry's "Flying Laboratories" engineers are testing Sperry automatic equipment under actual low weather conditions. From their accurate data come developments that *anticipate* the equipment needs of both commercial airlines and the military.

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Books

Jet Propulsion Progress; The Development of Aircraft Gas Turbines. Leslie E. Neville and Nathaniel F. Silsbee. New York, McGraw-Hill Book Co., Inc., 1948. 232 pp., illus., diagrs. $3.50.

On August 27, 1939, a Heinkel airplane rose into the air powered by the first turbojet engine to fly. The British flew the Whittle turbojet first on May 15, 1941, and the first jet-propelled flight in the U.S. took place on October 1, 1942. These three dates furnish a rough pattern of the aircraft gas turbine development that led to actual production. As the authors of this excellent book observe, the Nazis beat us to it, the British were early, too, and the U.S. pulled a miracle. This book tells not only what the German jet plane could do in combat, but gives a good account of the research that led to actual jet flight and of work currently in progress. Forty-nine pages are given to German gas turbine developments, forty-three to British developments, and eighty-two to American developments. The clear and accurate handling of detailed technical discussions and descriptions and the naming of key engineers and companies throughout the account are characteristic of the informed methods of the authors. Final chapters deal with problems of metallurgy, fuels, and maintenance, and with applications of the gas turbine in civil, military, and personal airplanes and helicopters. A chronology, a glossary, and a bibliography of books and articles add to the value of the book as a reference. A foreword is contributed by Dr. Jerome C. Hunsaker, who observes: "The present volume fills a need for a book covering international developments in the aircraft gas turbine from an American point of view. The authors have been in a position to follow these developments closely, and they have presented them objectively, clearly, and accurately." Mr. Neville is Director of the Standard Aeronautical Index of the Institute of the Aeronautical Sciences. Colonel Silsbee is managing editor of *Aero Digest*.

Problems of Accelerating Aircraft Production During World War II. Tom Lilley, Pearson Hunt, J. Keith Butters, Frank F. Gilmore, Paul F. Lawler. Boston, Harvard University, Graduate School of Business Administration, January 30, 1946 (Published October, 1947). 112 pp., diagrs. $1.50.

For information on I.A.S. Library Service Facilities, see page 51

Based on a research project carried out in 1945 for the Air Coordinating Committee's Subcommittee on Demobilization of the Aircraft Industry, the purpose of this report is to analyze the kinds of problems that had to be solved by Government and industry before the wartime production goals could be achieved. These are summarized as the absence of a unified national will to support industrial mobilization prior to Pearl Harbor, the limited number of fully developed, tactically useful models ready for production, the need to solve Government administrative problems and industry management problems which could have been minimized by preplanning, administrative problems of company management caused by the 70-fold expansion of the industry, and shortages of facilities at the beginning, materials after production was under way, and manpower toward the end. Statistical data up to the end of 1944 are included, and the report is a useful summary for both past and future reference.

Weapons of World War II. G. M. Barnes. New York, D. Van Nostrand Co., Inc., 1947. 317 pp., illus. $7.50.

A complete description of the weapons developed by the Ordnance Department of the U.S. Army in cooperation with science and industry and used in World War II. The chapters on aircraft armament, ammunition (including bombs), rockets and launchers, artillery (including anti-aircraft weapons), and research and materials are of special interest. Specifications and performance data are included for each weapon and details of its use in combat. The final chapter on research and materials, while brief, furnishes an outline of ordnance research accomplishments on new materials and processes, fuels and lubricants, and ballistics. The electronic computing device, supersonic wind tunnel, aerodynamic spark range, and the ballistic camera are some of the developments described. The book is well illustrated with photographs and drawings.

The Australian Aviation Yearbook, 1947–48. Edited by Stanley Brogden. Melbourne, Australia, The Hawthorn Press; South Pasadena, Calif., Distributed by P. D. and Ione Perkins, 1947. 224 pp., illus. $3.75.

This is the first complete directory and survey of aviation in Australia, covering civil and military government agencies, both administrative and research, airports, air lines, manufacturers of aircraft and components, repair stations, distributors, societies, gliding clubs, private aircraft owners, aerial medical services, and the aviation press. Articles on air transport, aerial surveys, aeronautical research, colleges, insurance, the aero club movement, gliding and Australian civil aviation history are included. Statistics included are for the year ending June 30, 1946. The completeness of the directory information, including names of personnel, adds to the usefulness of the volume.

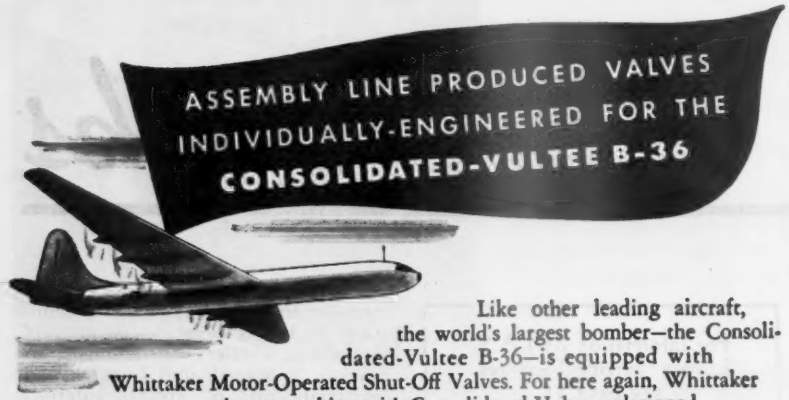
Other Books Received

AERODYNAMICS

Introduction to Theoretical Gas Dynamics. Robert Sauer. Translated by Freeman K. Hill and Ralph A. Alpher. Ann Arbor, Michigan, J. W. Edwards, 1945. 222 pp., illus. $3.50. This first English translation of Dr. Sauer's well-known work is based on his lectures at Göttingen in 1940, presenting a survey of the basic theory of compressible and supersonic flow. The translators are associated with the Applied Physics Laboratory of The Johns Hopkins University. Footnote references to sources are given, and an index is included.

BIBLIOGRAPHY

List of Translations Made by or Received in TPA 3/TIB During the Period 1935 to 1946 Inclusive. Compiled and issued by TPA 3, Technical Information Bureau. London S.W.1 (Thames House, Millbank), Ministry of Supply, 1947. 296 pp. The translations listed are those made or received in R.T.P., Air Ministry and Ministry of Aircraft Production, or R.T.P./T.I.B., Ministry of Supply, during the period 1935 to December 31, 1946. They are mainly translations of articles connected with aeronautical research, development, production, and operation. They



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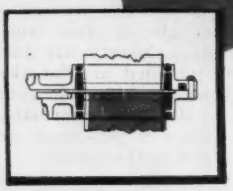

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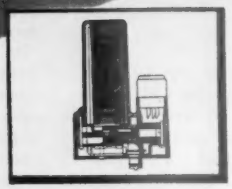

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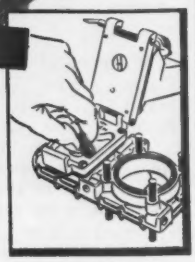

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are listed under eleven subjects of pure science and 16 subjects of applied science. The number, title, author, and original source of each translation is given.

ELECTRONICS

Electronic Engineering Patent Index. Edited by Frank A. Petraglia. New York, Electronics Research Publishing Co., 1946. 476 pp., diagrs. $14.50. A compilation of about 2,000 electronic engineering patents of 1946 arranged under 93 subjects. The patents are reproduced in full from the *Official Gazette of the U. S. Patent Office* for 1946. The first of a proposed annual series, this is a useful compilation for the location of patents on electronic components, circuits, and manufacturing processes and their applications in such typical fields as aeronautical radio systems and devices, beacon systems, direction finders, electronic control systems, radar and radio ranging systems, and radio compasses. Unfortunately, a name index is not provided.

Electronic Transformers and Circuits. Reuben Lee. New York, John Wiley & Sons, Inc., 1947. 282 pp., illus., diagrs. $4.50. A specialized work dealing with those phases of transformer design pertinent to electronic transformers and with the effects of transformer characteristics on electronic circuits. It is intended for use as a reference book on the design of transformers for electronic apparatus and as aid to electronic equipment engineers who are not fully acquainted with the way transformer characteristics influence the circuits in which they are installed. While mathematical proofs are kept to a minimum, the bases for quantitative results are indicated. The author is an advisory engineer for the Westinghouse Electric Company, and the book should be welcomed as a valuable contribution to the engineering literature on electronics. There is an appendix containing an analysis of the electrical characteristics of certain types of transformers and of the voltage rise in a reactor. A bibliography of 71 items covering nine subjects is included.

Fundamental Electronics and Vacuum Tubes. Arthur Lemuel Albert. Rev. Ed. New York, The Macmillan Co., 1947. 499 pp., diagrs. $6.00. First published in 1938, this text is designed for use in college and university courses on the fundamentals of electronics and vacuum tubes. It treats electronics as basic to both the communications and power fields. In this revised edition, the latest standards of the American Institute of Electrical Engineers and the Institute of Radio Engineers have been followed. Over 250 references are given at the ends of chapters. The author is a professor of communication engineering at Oregon State College.

Electronic Engineering Principles. John D. Ryder. New York, Prentice-Hall, Inc., 1947. 397 pp., diagrs. $6.65. The aim of the author is to supply an understanding of the physical background involved in emission, space charge, and gaseous conduction phenomena, leading to an understanding of electron tubes as electric circuit elements. Knowledge of basic a.c. network theory is assumed. Electronic engineering is approached as an independent field applicable to power or radio applications of electron tubes. Theory and applications are closely grouped, and applications are chosen largely from the industrial field. The author is a professor at Iowa State College.

Fundamentals of Industrial Electronic Circuits. Walter Richter. New York, McGraw-Hill Book Co., Inc., 1947. 569 pp., diagrs. $4.50. The text was prepared primarily for use in teaching evening courses. It should prove useful to the student who is not familiar with higher mathematics and to the electrical engineer who is not familiar with electronic circuits. The fundamental principles of electronic circuits have been stressed rather than specific applications. The author is a consulting electrical engineer with the Allis-Chalmers Manufacturing Company.

Modern Electrical Engineering Mathematics; An Introduction to the Mathematical Methods More Recently Employed in Electrical Engineering Theory, with Special Reference to Stationary Linear Networks. S. Austen Stigant. London,

Hutchinson's Scientific and Technical Publications, 1946. 369 pp., diagrs. 31*s.* 6*d.* The author's aim is to present, in simple introductory form, outlines of some of the progress that has been made in the application of the results of pure mathematical research to the solution of problems in electrical engineering theory and practice. Pointing out that these methods have produced important practical results, the author cites the case of the theory of symmetrical components applied to the analysis of unbalanced electrical networks and machines. Applications are confined to static plants and networks. Useful bibliographies of books and papers are appended to most chapters.

Understanding Vectors and Phase. John F. Rider and Seymour D. Ulsan. New York, John F. Rider, Publishers, Inc., 1947. 149 pp., diagrs. $0.99. This text is intended for those who use vectors and phase in daily work and wish to keep abreast of electronic developments, and as an aid to radio servicemen, technicians, and students not seeking engineering training.

FLIGHT TECHNIQUE

Airline Transport Pilot Rating. Charles A. Zweng and Allan C. Zweng. 3rd Rev. Ed. North Hollywood, Calif., Pan American Navigation Service, 1947. 541 pp., illus., diagrs. $4.00. This book is intended for airmen seeking the Government air-line transport pilot rating. Four subjects on which the text is based, radio, Civil Air Regulations, meteorology, and navigation, are thoroughly covered. Anticipating future needs, a section on instruments has been added to the text and the review questions in this edition. The major part of the text has been revised, and new materials on meteorolgy and navigation added. Special procedures in radio direction finding, navigation problems, and the new weather maps are included in the question section.

Instrument Flying. P. V. H. Weems and Charles A. Zweng. 2nd Ed. Annapolis, Weems System of Navigation; North Hollywood, Calif., Pan American Navigation Service, 1947. 482 pp., illus. $4.00. The first edition was published in 1940 and was based on the original work of Howard Stark. This second edition has incorporated changes made in the Civil Air Regulations, and includes a new chapter on Attitude Instrument Flight, as well as much new material on radio aids to navigation and weather forecasting. The appendix, containing multiple choice examinations, covers over 100 pages including 275 typical questions and answers. For candidates for the U.S. Government instrument rating.

MANAGEMENT

Industrial Management. William R. Spriegel. 4th Ed. New York, John Wiley & Sons, Inc., 1947. 656 pp., illus., diagrs. $5.00. A new edition of the textbook originally written by Richard H. Lansburgh, which was last revised in 1940. Both the college student and the business executive have been considered in the preparation of the book, whose aim is to establish a balance between theory and practice and to show throughout the relationships and interdependence of the various major departments of a business. The text has been developed from the point of view of the medium-sized plant, though frequent reference is made to the large and the small enterprise. The author is a professor at Northwestern University.

MATERIALS

Essay in Rheology. Based on the 1944 Oxford Conference of the British Rheologists' Club. New York, Pitman Publishing Corp., 1947. 103 pp., diagrs. $4.00. The papers of a 4-day conference held in 1944 are coordinated and condensed into seven chapters on different aspects of the deformation of materials. Among the papers are: The Plasticity of Metals, by E. Orowan; The Relationship Between Compression and Shear Tests, by R. L. Brown; The Time-Variations of Stress and Strain, by S. Whitehead and W. Lethersich; Rheological Nomenclature and Symbols, by H. O'Neill; and Rheology and Naval Problems, by Sir Charles Goodeve.

American Society for Testing Materials. Proceedings. Vol. 46, 1946. Committee Reports, Technical Papers. Philadelphia, The Society, 1947. 1,629 pp., diagrs. $15. Partial contents: The Notch Sensitivity in Fatigue Loading of Some Magnesium-Base and Aluminum-Base Alloys, George H. Found; The Fatigue Strength of Some Magnesium Sheet Alloys, L. R. Jackson and H. J. Grover; Fatigue of Wood and Glued-Wood Constructions, W. C. Lewis; Resistance of Iron-Nickel-Chromium Alloys to Corrosion in Air at 1600° to 2200°F., Anton deS. Brasunas, James T. Gow, and Oscar E. Harder; Compressive Properties of Aluminum Alloy Sheet at Elevated Temperatures, Alan E. Flanigan, Leslie F. Tedsen, and John E. Dorn; Tensile and Creep Strengths of Some Magnesium-Base Alloys at Elevated Temperature, A. A. Moore and John C. McDonald; Compressive Stress-Strain Properties of Some Aircraft Materials, P. E. Sandorff and R. K. Dillon; Evaluation of the Forming Properties in Bending of Five Commercial Sheet Aluminum Alloys, G. R. Gohn and S. M. Arnold; The Notch Sensitivity in Static and Impact Loading of Some Magnesium-Base and Aluminum-Base Alloys, J. P. Doan and J. C. McDonald; Mechanical Methods of Testing Analysis of the State of Stress in the Neck of a Tension Test Specimen, N. N. Davidenkov and N. I. Spiridonova; A Study of the Tension Test, Earl R. Parker, Harmer E. Davis, and Alan E. Flanigan; A Study of the Geometry of the Tension-Impact Specimen, N. A. Kahn and E. A. Imbembo; The Theoretical Basis of Adhesion, W. A. Weyle; and The Comprehensive Laboratory Testing of Instrument Lubricants, G. E. Barker, G. E. Alter, Jr., C. E. McKnight, J. R. McKlveen, and D. M. Wood.

Symposium on Rubber Testing. 15th Annual Meeting, American Society for Testing Materials. (Special Technical Publication No. 74.) Philadelphia, American Society for Testing Materials, 1947. 109 pp., diagrs. $2.00. These eight papers and discussions cover physical and chemical methods of test on synthetic and natural rubbers, making available data that were classified for security reasons during the war. The importance of standardization in the rubber industry is stressed.

Radiography in Modern Industry. Rochester, N.Y., Eastman Kodak Company, X-Ray Division, 1947. 122 pp., illus., diagrs. This text is intended for the serious professional worker as well as the student reader and aims to supply the fundamental knowledge necessary for radiographic practice. A bibliography of 94 books and articles is included.

Handbook of Ordnance Radiography. (U.S., Navy Department, Bureau of Ordnance, Ordnance Pamphlet No. 1681.) Washington, U.S. Govt. Printing Office, 1946. 197 pp., illus., diagrs. $0.65. A practical handbook designed for the use of personnel engaged in the inspection of ordnance materials by the use of radiographic processes. Sufficient theory is included to enable the user to understand the fundamental processes of radiography. A brief bibliography is appended.

MECHANICS

Engineering Mechanics. Seibert Fairman and Chester S. Cutshall. 2nd Ed. New York, John Wiley & Sons, 1946. 267 pp., diagrs. $3.00. In this new edition of a textbook first published in 1938, new problems have been inserted throughout, and a chapter has been added on the product of inertia and moments of inertia about principal axes, primarily for the benefit of aeronautical engineering students in connection with unsymmetrical bending. The authors are professors at Purdue University.

METEOROLOGY

Classified Flying Weather for the United States: Percentage Frequencies of "Contact," "Instrument," and "Closed Weather." U.S., Weather Bureau, Division of Climatological and

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Hydrologic Services, Aviation Section. Washington, U.S. Govt. Printing Office, December 1946. 300 pp. $1.00. These data were compiled by tabulating the occurrences of contact, instrument, and closed weather at all Weather Bureau controlled airports, and at all Army airports in the continental United States for which such records were available. A convenient and quick method for determining flying weather at each of more than 425 stations and for comparison of weather at two or more stations.

MILITARY AVIATION

Flying Minute Men; The Story of Civil Air Patrol. Robert E. Neprud. New York, Duell, Sloan & Pearce, 1948. 232 pp., illus. $3.00. This is an authentic history of the growth and achievements of the Civil Air Patrol, organized a week before Pearl Harbor, and its conversion to a postwar aviation program. It was prepared for the Director of Public Relations, Department of the Air Force, and contains a foreword by General H. H. Arnold.

PRODUCTION

Manufacturing Processes. Myron L. Begeman. 2nd Ed. New York, John Wiley & Sons, Inc., 1947. 626 pp., illus. $5.00. This edition of a book first published in 1942 contains new chapters on special casting methods, powder metallurgy, and hot and cold forming of metals. The chapter on plastic molding has been rewritten, and much of the chapter on welding and allied processes. Material on newly designed machines and tools has been included throughout.

Le Plan de Fabrication Aéronautique (The Plan for Airplane Production). M. P. Guibert. Paris, Dunod, 1945. 126 pp., diagrs. 255 fr. The aim of this book is to present a method of determining a plan for the production of a given aircraft, and to illustrate it graphically. Considering such a plan as a cardinal factor in production, the author undertakes to limit the possibility of basic errors and to indicate a number of methods requiring the rigorous mathematical study of production. Particular attention is paid to the introductory period of production of a given aircraft. The methods outlined are supported by statistical data, including the number of productive workers required for each type of machine tool or each operation, the number of workers required for "nonproductive" duties, and the floor space required for different types of machines. Supporting data are adjusted for various monthly rates of production.

REFERENCE BOOKS

Jane's All the World Aircraft, 1947. Compiled and Edited by Leonard Bridgeman. (Thirty-Fifth Year of Issue.) New York, The Macmillan Company, 1947. 447 pp., illus., diagrs. $30. This year's letterpress American edition is a great improvement over the photo-offset reproductions of previous years, principally because of the clarity in the photographs. A detailed review of the 1947 edition was published in the AERONAUTICAL ENGINEERING REVIEW for November, 1947.

ROTATING WING AIRCRAFT

Vertical Flight. Parlee C. Grose. McComb, Ohio, General Publishing Co., 1947. 18 pp., illus. $1.00. A collection of five papers: Further Notes on the Problem of Vertical Flight; The Prime Functional Essentials of a Vertical-Flight Craft; Beedynamics; The Rotary Wing; and Magnus-Effect Rotor Lift.

STRESS ANALYSIS

Proceedings of the Society for Experimental Stress Analysis. Vol. 5, No. 1. Edited by C. Lipson and W. M. Murray. Cambridge, Mass., Addison-Wesley Press, Inc., 1947. 136 pp., illus., diagrs. $6.00. Contents: Explosive Impact Tests, Paul R. Shepler; Criterion of Static and Fatigue Failures, Albert Sniderman; The Experimental Determination of the Dynamic Structural Response of an Airplane to Impact Loadings, W. M. Claflin; A Proposed New Shock Measuring Instrument, W. P. Welch; Radio Pulse Telemetering, Conrad H. Hoeppner; Method of Obtaining the Stress at the Mid-Thickness by Measurements from Only One Surface of a Plate, A. Bloodberg and E. D. Howe; Bonded Wire Strain Gage Techniques for Polymethyl Methacrylate Plastics, A. G. H. Dietz and W. H. Campbell; Effect of Temperature Gradients upon the Introduction of Residual Stresses in Weldments or Other Structures, J. R. Stitt; Recent Contributions to the X-Ray Method in the Field of Stress Analysis, J. T. Norton and D. Rosenthal; Lateral Vibration and Stress in a Beam Under Shock Machine Loading, E. G. Fischer; High-Temperature Strain Gages and Their Application to Measurement of Vibratory Stresses in Turbosupercharger Buckets, S. S. Manson, R. H. Kemp, and W. C. Morgan; Some Characteristics of Navy "High Impact" Type Shock Machines, Irwin Vigness; Electronic Commutation of Strain Gages for Telemetering, Lawrence Lee Rauch; Determination of the Effect of Ground Impact Forces in the Airplane Drop-Test, A. H. Pedersen and J. G. MacCarthy.

VIBRATION

Cooperative Testing of Torsiographs and Calibrators. U. S. Navy and the Society of Automotive Engineers. New York, Society of Automotive Engineers, Inc., Technical Board, 1947. 98 pp., illus., figs. $3.00. A report of tests carried out to obtain information on applications, variations, accuracy, reproducibility, and significance of results using various instruments for the measurement of torsional vibration. The report also covers the testing and development of two simplified torsiographs supplied by the General Motors Research Division and Chrysler Research Laboratories as a possible solution to the Navy's need for simplified torsiograph instrumentation.

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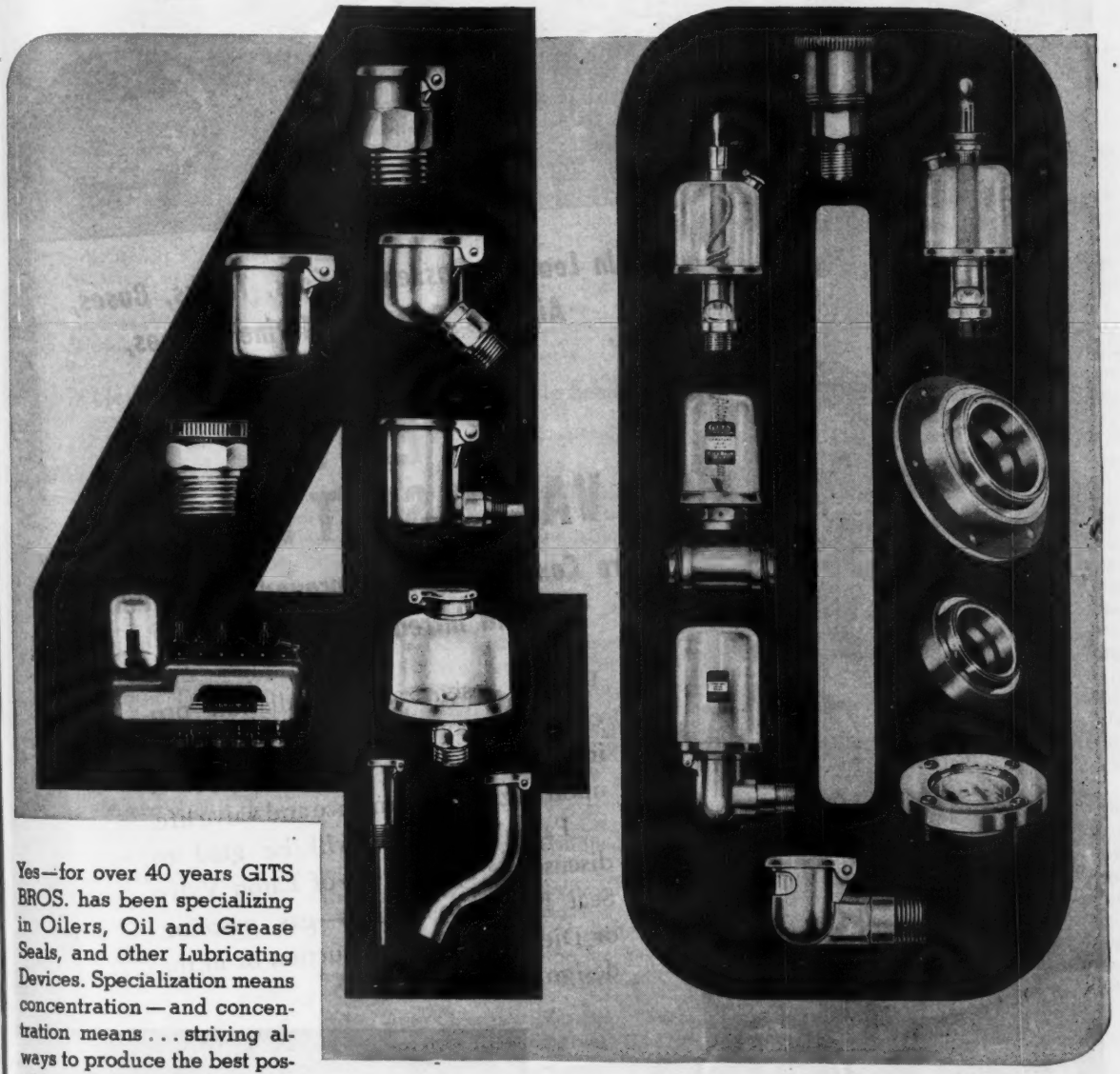

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Sections and Branches

(*Continued from page 13*)

Program Committee—Capt. C. H. Schildhauer.
Technical-Papers Committee—S. A. Gordon.
Constitution and By-Laws Committee—Capt. G. J. Higgins.
Membership Committee—Preston Layton.

▸ **C-82 Features Discussed**—At the conclusion of the business meeting, Mr. L. Fahnestock, Assistant Chief Engineer, Fairchild Aircraft Division of Fairchild Engine & Airplane Corporation, spoke on the C-82 Packet. Tracing the origin and development of the plane, he reviewed the present status of the project, touching briefly on future improvements contemplated for the C-82.

The discussion was well illustrated by slides, which showed not only views of the transport but also presented much comparative data with other aircraft transports.

New York Section

E. M. Lester, *Secretary*

With 200 attending, the New York Section conducted an experimental type of meeting January 9 consisting of unrehearsed discussion between members of the forum on aircraft propulsion subjects. Chairman William R. Enyart presided.

The discussions were led by the Moderator, E. M. Lester, Secretary of the Section, to cover the fields of power-plant application design and performance. Since representatives of manufacturers of all types of aircraft engines were present, several interesting discussions were precipitated relative to the merits of various types of power plants.

Following the forum discussion, the Moderator opened the session to questions from the floor, which contributed substantially to the overall discussion.

▸ **Favorable Reaction**—Many favorable comments were received from members attending the forum. It was indicated that this type of meeting appeared attractive as a source of information and understanding of the problems discussed.

It is hoped that it will be possible to conduct future meetings on the same principle.

The forum members were: Joseph Alford, Aviation Gas Turbine Division, General Electric Company; Kenneth Campbell, Wright Aeronautical Corporation; Arnold Reading, Aviation Gas Turbine Division, Westinghouse Electric Corporation; Alfred T. Gregory, Ranger Aircraft Engines; William Munger, Reaction Motors, Inc.; and Perry Pratt, Turbine Department, Pratt & Whitney Aircraft Division, United Aircraft Corporation.

Philadelphia Section

John Rogers, *Secretary*

Meeting January 14, 52 members of the Section engaged in the first "Information Please" program sponsored by the Section. Presiding at the meeting was Comdr. Paul J. Burr, U.S.N.R. F. G. Tatnall was Moderator.

▸ **Lively Discussions**—Members were invited to ask a question, start a debate, or present their views on any phase of aviation. This type of meeting resulted in lively discussions, and members welcomed the opportunity to take an active part in the program. Many phases of aviation were covered.

Seattle Section

Vaughn Blumenthal, *Secretary*

At the January 13 meeting of the Section, Carl Griffen, Chief Flight Superintendent, Western Division, Northwest Airlines, Inc., gave a talk on "Northwest Airlines Route to the Orient." The meeting was presided over by Jere Farrah, Chairman.

▸ **New Strategic Route**—Mr. Griffen actively participated in the establishment of this new strategic route "over the top" to the Orient, including setting up navigational facilities, airports, and even small towns made up almost exclusively of NWA employees at some of the isolated way stations.

Mr. Griffen outlined some of the difficulties encountered in establishing a new route in virgin air-line territory. Particular emphasis was laid on the lack of housing, suitable office and hangar space, the language barriers, and lack of navigational aids.

▸ **Chicago Weather Worst**—The common assumption that weather along the Aleutian chain was the major obstacle to "over the top" flights was proved wrong, with Northwest experiencing worse weather around the Chicago area than it does "up north."

The speaker stressed two points: (1) that routine, scheduled flying is being accomplished, and (2) that no point on the route is more than 1 hour from an acceptable landing field.

There was an attendance of 80 at the meeting.

Washington Section

Milton B. Ames, Jr., *Secretary*

At the December 15 meeting, members of the section received two first-hand reports on the joint R.Ae.S.-I.A.S. meeting in London held last September.

The speakers were T. P. Wright, newly appointed President of the Cornell Research Foundation and Vice-President of Cornell University, and R. G. Robinson, Assistant Director of Aeronautical Research, National Advisory Committee for Aeronautics.

▸ **General Account**—Mr. Robinson presented a general chronological account of the joint Anglo-American meeting and praised the British for their hospitality, which was accomplished in spite of their many difficulties.

He stressed the necessity that members of the Institute reciprocate in kind when similar meetings are held in this country. Reporting on the excellent quality of the technical papers presented in London, Mr. Robinson added that their summary nature befitted the occasion.

The talk was illustrated by color films which he took during his visit in England.

▸ **Detailed Review**—Dr. Wright reviewed in some detail the various commercial aircraft developments in England at the present time. In discussing the various design projects by classes, such as transports, freighters, personal planes, helicopters, and flying boats, he noted the emphasis given by the British to large commercial transports, flying boats, and freighters. In Dr. Wright's opinion, one of the outstanding features in British progress is their turboprop development.

Both Mr. Robinson and Dr. Wright agreed on the desirability of establishing the Royal Aeronautical Society-Institute exchange meeting arrangement during peacetime without waiting for war to bring our countries together. There is nothing more important, Dr. Wright said, than a continuation of such collaboration in aircraft matters.

Cal-Aero Technical Institute

Volmer Jensen, of Volmer-Carrson, Inc., makers of the Volmer VJ-21 aircraft, was the principal speaker at the Branch's January 13 meeting, Chairman Francis L. Wright presiding.

The meeting was opened by Carl A. Tamarin, Secretary-Treasurer, the only remaining officer, who introduced the newly elected Chairman, Francis L. Wright, and Vice-Chairman Alf Lied.

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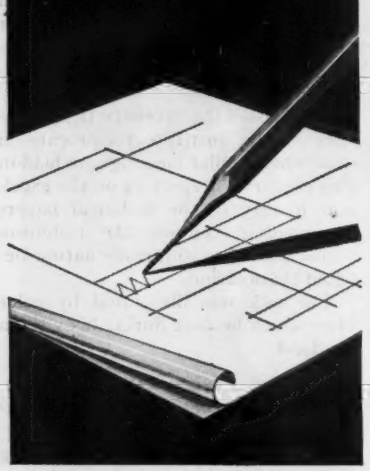

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Jensen gave an interesting talk on the problems of design of his VJ-21. His talk was accompanied by a film illustrating his points.

Two additional films were shown: *The Antarctic Expedition*, from the Army-Navy Screen Magazine Service, and *Aero-Oddities*.

There were 120 members present.

University of Illinois

There being no scheduled speaker for the January 7 meeting, Prof. H. S. Stillwell had requested the use of the regular session to explain changes in the aeronautical engineering curriculum which were to go into effect at the beginning of the spring term.

Following a question-and-answer period, a new faculty sponsor was selected—Prof. Jacque Houser to replace Prof. R. W. McCloy, who had served in that capacity for 2½ years—and a new board of officers was elected for the coming semester. Results were as follows: Chairman, Edward J. Brisick; Vice-Chairman, Vernon F. Van Heyningen; and Secretary-Treasurer, Henry C. Lessing.

University of Minnesota

For the purpose of acquainting the underclassmen with the faculty of the Aeronautical Engineering Department, the Chairman, Louis F. Heilig, invited Prof. John D. Ackerman, Head of the Department, to address the meeting of January 14. There were 150 in attendance.

Professor Ackerman spoke on the future of aeronautical engineering, both nationally and at the university, and of the recent acquisition of the Rosemont Ordnance Plant by the university for research purposes.

The Secretary, Harry T. Swanson, gave a short talk on the R.O.T.C. program, dealing especially with the Air Force branch.

University of Notre Dame

At the January 15 meeting, attended by 35 members, a motion was made and carried to send an appropriate gift to the Chairman, Joe O'Hara, who was injured in an auto accident on December 19. Vice-Chairman Walter Marut presided and introduced the speaker of the evening, Clayton C. La Verne, Engineering Employment Manager, Douglas Aircraft Company, Inc., who spoke on "Employment Opportunities with Douglas Aircraft Company."

A film, *PBM-3 Wing Destruction Test*, was also shown.

memorandum

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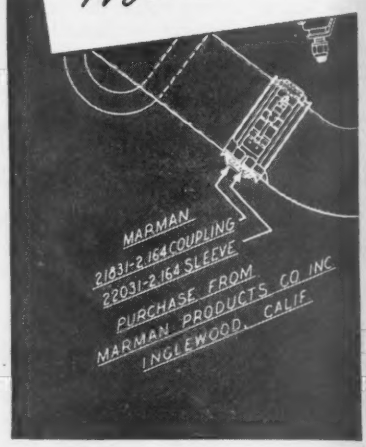

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Parks College of Aeronautical Technology

The film, *Smoke Flow*, shown at the January 15 meeting of 25 members of the Branch, was preceded by a discussion of circulation and momentum theory led by Mr. Perkinson, aerodynamics instructor.

Smoke Flow showed the effects of shape and angle of attack on the forces of lift and drag.

Chairman Richard A. Dean presided.

Spartan College

In a meeting presided over by the Secretary, Franklin T. Nelson, January 8, new officers were elected by the 56 members present. The new officers are: Ernest J. Merz, Chairman; Charles Gruenberg, Secretary; and Judson A. Kizer, Treasurer.

Virginia Polytechnic Institute

The first meeting of the new quarter was held January 8. Following a business session, a film, *Martin 2-0-2*, was shown. Chairman James L. Saffell presided at the meeting attended by 85.

The January 27 meeting was held jointly with the student branch of the American Institute of Electrical Engineers, Chairman James L. Saffell presiding.

Two films were shown—*Jet Propulsion* and *Planes Without Pilots*. There were 80 members in attendance.

News of Members

Alfred A. Adler resigned from N.A.C.A. Langley Memorial Aeronautical Laboratory to become Research Aerodynamicist at Cornell Aeronautical Laboratory.

John D. Ahlers is President, Flight Training System, Inc. He had been Chief, Aircraft Branch, Operations Division, Foreign Liquidation Commission, Rio de Janeiro Office.

Walter Banas, formerly Weights Group Leader, Canadair Ltd. (Canada), is now attending the University of Colorado, where he is completing his professional education.

Major Chester H. Brown, Jr., is a staff member at Massachusetts Institute of Technology.

Michael Angelo Caruba, formerly an Engineer with Brewster Aeronautical Corporation, now is Engineer with Republic Aviation Corporation.

Thomas W. Chase is Assistant Scientist-Aeronautical Laboratory, University of Minnesota.

Frank W. Fink

Carl Spencer Couchman resigned as Service Engineer with Republic Aviation Corporation to go into business for himself as Consultant.

Adams Craigon is Director of Research and Development, High Speed Motors Corp. Ltd. (Canada).

Joseph A. Ebin, Army veteran, is with North American Aviation, Inc., as Stress Analyst.

Frank W. Fink has been appointed Chief Engineer of Consolidated Vultee Aircraft Corporation's San Diego division.

Thomas Heffernan, formerly with The Ryan Aeronautical Company, is Staff Engineer, Anderson-Nichols & Company.

Joseph K. Keelaghan is Stress Analyst, Douglas Aircraft Company, Inc.

John O. Loney is owner of the Loney Aviation Service.

Robert G. Melrose, formerly Technical Liaison Manager, Military Contracts Department, now is Sales Engineer, Republic Aviation Corporation.

Donald J. Naumann is Designer-Preliminary, North American Aviation, Inc.

John J. O'Brien, former Stress Analyst with The Ryan Aeronautical Company, is Physicist, U.S. Navy Ordnance Test Station, Navy Department.

Vernon W. Payne is Chief Designer & Engineer, Knight Twister Aircraft Company.

Claude F. Riley, Jr., was named Research Associate in Propulsion-Aeronautical Research Center, University of Michigan.

Jack Shiff is Engineer, Langley Memorial Aeronautical Laboratory, N.A.C.A.

Albert B. Scoles, recently appointed Director of Technical Liaison, Pilotless Plane Division, Fairchild Engine & Airplane Corporation, has been retired from the Navy with the rank of Rear Admiral.

Clifford P. Seitz, a Lieutenant, U.S.-N.R., is Consultant, Aviation Psychology, Flight Section, Special Devices Center, Office of Naval Research.

Samuel S. Shaw, a Lieutenant Commander in the Naval Reserve, is Staff Engineer, Booz, Allen & Hamilton.

John Calvin Silliman is Assistant Project Engineer, Northrop Aircraft, Inc.

Donald W. Smith, former Test Engineer with Douglas Aircraft, has been named Aeronautical Research Scientist, Grade P-2, Ames Aeronautical Laboratory, N.A.-C.A.

James B. Sterling resigned from United Air Lines to become Aeronautical Engineer, Pan American World Airways System.

Nathan F. Vanderlipp is with The Glenn L. Martin Company as Factory Manager. He had been General Manager, Bellanca Aircraft Corporation.

Jose Luis Velazquez is Structures Engineer, North American Aviation, Inc.

Clifford E. Weihman is Aerodynamicist with The Glenn L. Martin Company.

George White, former President and General Manager of Dansaire Corporation, is Aeronautical Engineer, Langley Memorial Aeronautical Laboratory, N.A.C.A.

Samuel Yudewitz has been named Aerodynamics Engineer, Kellett Aircraft Corporation.

Necrology

Richard H. Depew, Jr.

Richard Henry Depew, Jr., Associate Fellow and a pioneer pilot, died January 28 at his home in Garden City, Long Island, N.Y. He was 55 years of age.

At his death, Mr. Depew, who had held many important positions in the aviation industry, was Director of Domestic Sales for the Frank Ambrose Aviation Corporation of Flushing, L.I. In 1945–1946, he was Chief of the Aircraft Disposal Section of War Assets Administration.

Richard H. Depew, Jr.

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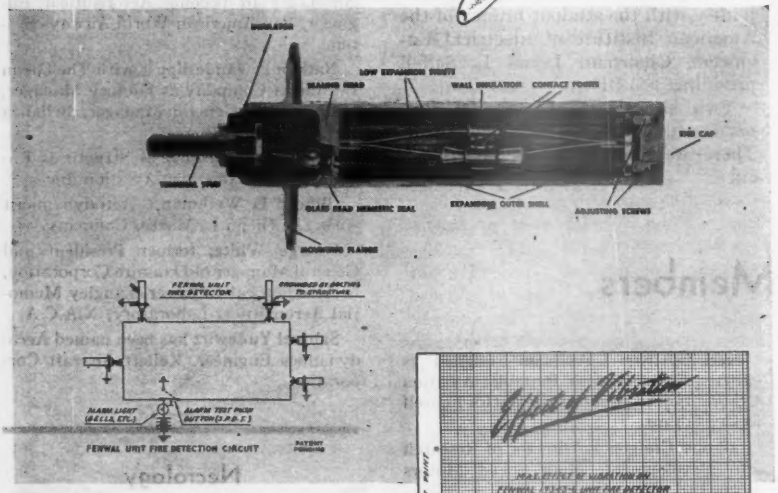

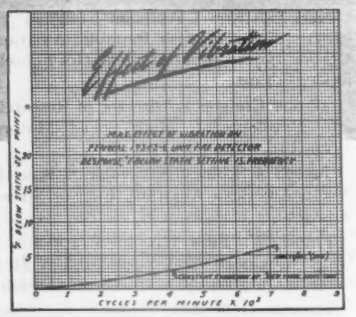
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Receiving the Fédération Aéronautique Internationale pilot license No. 641 from the Aero Club in France October 6, 1911—he was the second youngest pilot in the world at that time—Mr. Depew accumulated a wide experience in flying, including 155 types of airplanes, three types of autogiros, and two types of gliders. He made the world's first flight with no crankshaft, using the Caminez "Cam" engine, in 1926.

His aviation career, the variety of which was equalled by few, included the roles of experimental test pilot, instructor, Army officer, exhibition pilot, and cross-country flying, aerial photography, and sales demonstration work. He was at the controls of the first Government mail plane flight—the test flight of the Curtiss JN-4-HM at Buffalo on April 13, 1918. Altogether, Mr. Depew had logged more than 3,000 hours in the air.

Born in Plainfield, N.J., May 20, 1892, he attended Taft School and Cornell University College of Engineering. He learned to fly at the Maurice Farman School at Buc, France. From 1911 to 1917 he studied aeronautics while engaged in other occupations. Among his aviation industry connections, he was with Curtiss Aeroplane & Motor Corporation, and Curtiss Exhibition Company, as Manager, Curtiss Aviation School (1919–1922); Manager, Curtiss Flying Field (1922); Argentine Manager, Curtiss Aeroplane Export Company, at Buenos Aires (1922–1923); various capacities with Fairchild Aviation Corporation, including Chief Pilot; Manager, Flying Division; Vice-President and Director, Fairchild Flying Corporation, etc. (1923–1931); flying and demonstrating the Pitcairn Autogiro for Giro Transport and Sales Co. (1932); Vice-President in Charge of Flying, and Manager, Aviation Country Club of Long Island, Inc. (1932–1934). From 1934–1938 he was associated with various aircraft distributors, and in 1938 became Executive Vice-President and General Manager and Director of Taylorcraft Aviation Corporation.

Mr. Depew also held a number of patents on airplane inventions, including a control surface operating mechanism (including folding wing) and wheel brake operating mechanism.

Col. V. Evans Clark

Colonel Virginius Evans Clark, Fellow of the Institute, died January 30 in the Santa Monica Hospital, Calif., at the age of 61. He was a consulting engineer for the Hughes Aircraft Company in Culver City.

Born in Uniontown, Pa., Colonel Clark was graduated from the United

States Naval Academy in 1907 and transferred to the Army Coast Artillery 2 years later. In 1913 he qualified as a pilot.

Promoted to captain following a period of study at Massachusetts Institute of Technology, he was made Chief Aeronautical Engineer of the Army in 1915, holding that post throughout the first World War. He became a lieutenant colonel in 1918 and served on technical and advisory aviation boards.

One of the founders of Consolidated Aircraft Corporation in Buffalo, N.Y., Colonel Clark won nation-wide fame in aviation for his wing designs. Among these were the airfoil for Lindbergh's Spirit of St. Louis, the Chance Vought Corsair, the Wright Apache, and other record-breaking planes of Douglas, Consolidated, Curtiss, and Martin plants.

Following his resignation from the Army in 1920, he became Chief Aeronautical Engineer of the General Motors Corporation at its Dayton plant. When General Motors discontinued its aviation activities, Colonel Clark helped organize Consolidated Aircraft.

In 1927 he represented the United States Chamber of Commerce at the International Aviation Congress in Rome.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Koneczny, W. Edmund, M.S.E., Chief, Airworthiness Section, U.S. Civil Aeronautics Board.

Russell, Archibald Edward, B.Sc., F.R.Ae.S., Chief Designer, Aircraft Div., Bristol Aeroplane Co. Ltd. (England).

Transferred to Associate Fellow Grade

Crowley, Donald Martin, B.Ae.E., Director of Ground Training, Flight Crew Personnel, Transcontinental & Western Air, Inc. (Kansas City).

Elected to MEMBER Grade

Alman, H. Victor, B.Sc., Stress Analyst, Douglas Aircraft Co., Inc.

Berg, Max Willard, B.S. in Ae.E., Research Aerodynamicist, Franklin Institute Laboratories.

Bertholf, Lloyd Bernard, B.S. in Ae.E., Meteorologist, Airline Weather Forecaster, Pan American Airways.

Bolz, Ray Emil, M. of Eng'g., Asst. Prof. of Aeronautics & Research, Rensselaer Polytechnic Institute.

Foulke, William Knight, B.Ae.E., Project Engineer, Aero. Ice Research Lab., Smith, Hinchman & Grylls, Inc.

Hord, Richard Nathaniel, B.S. in M.E., Power Plant Design Engineer, McDonnell Aircraft Corp.

Kelsey, Harold D., E.E., Manager, Aircraft Gas Turbine Div., General Electric Co.

Marsh, John C., Flight Test Engineer & Supervisor of Experimental Dept., Firestone Aircraft Co. of Pa.

Schamberg, Richard, Ph.D., Aerodynamics Engineer "A," Douglas Aircraft Co., Inc. (Project RAND).

Van Kirk, Harry Hill, Jr., Project Engineer, The Waco Aircraft Co.

Zwack, Raymond Theodore, M.E., Project Engineer, Turbine-Propeller Controls, Propeller Div., Curtiss-Wright Corp.

Transferred to MEMBER Grade

Allen, George Thomas, Design Engineer, Simmonds Aerocessories, Inc.

Bednarek, Michael Vincent, B.Ae.E., Engineering Designer, Douglas Aircraft Co., Inc.

Berlin, Daniel, Ae.E., Structures Engineer, East Coast Aeronautics, Inc.

Clementson, Gerhardt Christopher, M.S. in Ae.E., Capt., Engineering Test Pilot, U.S. Air Force—taking advanced courses in Stability & Control, Aero. Dept., M.I.T.

Ducoffe, Arnold Lionel, M.S. in Ae.E., Asst. Prof. of Aeronautics, Georgia School of Technology; also Research Engineer for State Engineering Experimental Station.

Gaugh, William James, M.S. in Ae.E., Aerodynamicist, Stability & Control Group, Northrop Aircraft, Inc.

Gilstad, Douglas Allan, B.Ae.E., Unit Head, Structures Engineer, Loads Group, Airplane Div., Curtiss-Wright Corp.

Kavanaugh, Edward Shea, B.S. in Ae.E., Asst. Prof. of Aero Engineering, University of Notre Dame.

Ledbetter, Girvis Erwin, B.S. in Ae.E., Research Engineer, Dept. of Aero. Engineering, University of Washington.

Lehman, Frederick Goodwin, S.M. in C.E., Asst. Prof. of Civil Engineering, Newark College of Engineering.

Low, Lawrence Jacob, M.E., Aerodynamicist (Research), Stability & Control Group, Cornell Aero. Lab.

Miles, John W., Ph.D. in E.E., Asst. Prof. of Engineering, University of California.

Suydam, Henry Bergen, B.S. in Naval Architect & Marine Engineering, Asst. Head, Tank No. 2 Section, Hydrodynamics Div., Langley Mem. Aero. Lab., N.A.C.A.

Thomason, Homer Spencer, Jr., B.S. in M.E., Static Test Engineer, North American Aviation, Inc.

Elected to Associate Member Grade

Deis, Frank Robert, Technical Aide & Project Engineer, 12-Ft. V.W.T., AMC (Wright Field).

Goldman, Leonard, Technical Translator, Intelligence Dept., Air Documents Div., AMC (Wright Field).

Powders, Howard F., Special Representative—Aviation, American Steel & Wire Co.

Prokosch, Walther, B.F.A., Vice-President, George S. Armstrong & Co. Inc.

Transferred to Associate Member Grade

Axtell, George Clifton, Jr., Major, Detail Officer, Personnel Section, Div. of Aviation, Headquarters, U.S. Marine Corps.

Elected to Technical Member Grade

Ferris, Herbert Henry, Jr., Asst. to the Director of Laboratories, Rohr Aircraft Corp.

Green, Leon, Jr., M.S., Research Engineer, Jet Propulsion Lab., GALCIT, California Institute of Technology.

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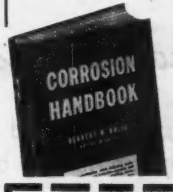

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Scott, Marion Autry, Master Linesman, North American Aviation, Inc.

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Shef, Arthur Leonard, B.S.E. (Math.) and B.S.E. (Ae.E.), Student, University of Michigan.

Smith, Hamilton Allen, B.Ae.E., Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Sturrock, James Parker, B.S. in G.E. (Ae. Option), Graduate Student, Aero. Engineering Dept., Georgia School of Technology.

Weinstein, Irving, B.S., Aero. Engineer, Langley Mem. Aero. Lab., N.A.C.A.

Weissman, Jerome, B.S.

Wolanski, Henry Stanley, B.S. in Ae.E., Rackham Graduate School, University of Michigan.

Wood, Raymond Jay, B.S. in Ae.E., Jr. Engineer, Babcock & Wilcox Co.

Aeronautical Reviews

(*Continued from page 77*)

High-Speed Wind Tunnels. Luigi Crocco. (*L'Aerotecnica*, Vol. 15, Nos. 3, 7–8, March, July-August, 1935, pp. 237–275; 735–778.) *U.S., Air Force, Translation No. 366*, 1947. 112 pp., diagrs. 5 references.

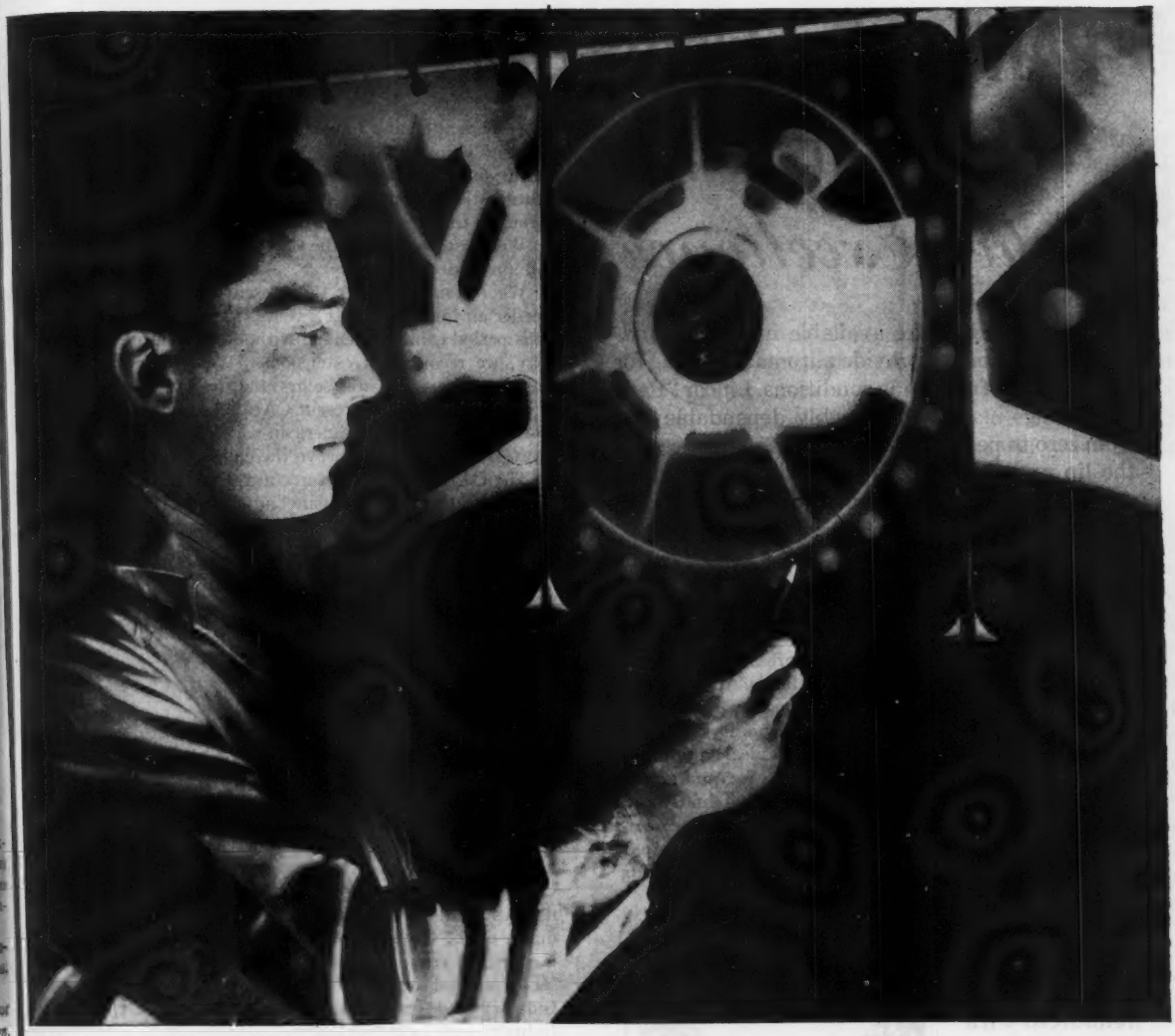
A detailed study of the various types of high-speed wind tunnels. A set of formulas is derived for the energy ratio and the power requirements per unit area of test section. Comparison of the results that are obtained when these formulas are applied to the closed-return and the open type of direct action and induction tunnels shows that the direct-action type is superior to the induction-type tunnel. The closed-return tunnel can be operated at reduced pressures, thus reducing the power requirement. Experimental data show shock compression to be less efficient than indicated by the theoretical analysis. Continuous compression has been found in practice to be more efficient than shock compression.

Atmospheric Testing; New de Havilland Test House for Research and Development in Pressurization and Allied Problems. *Flight*, Vol. 52, No. 2027, October 30, 1947, pp. 498, 499, illus.

Simulated-Altitude Testing; New D.H. Test Chambers for Airframe Components and Fuel Systems. *Aircraft Production*, Vol. 9, No. 110, December, 1947, pp. 441–443, illus.

Proceedings of Anglo-American Conference

All papers presented at the R.Ae.S.-I.A.S. joint conference in London in September have been published in book form by the Royal Aeronautical Society. A limited quantity of the books, containing 750 pages and covering all discussions of the papers and proceedings of the meetings, are now available in this country. Copies may be ordered from the Institute at $10 each for I.A.S. members and $12 for nonmembers.



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▸ This Wright technician is reading an X-Ray negative of a vital engine part. The penetrating X-Ray has revealed a small flaw *inside* the casting — where the sharpest human eye would never see it.

▸ But like your family doctor, the Wright engineer is more interested in preventing trouble than in curing it. The findings of X-Ray are not limited to the rejection of parts. Information about the behavior and qualities of metals is passed along to the foundryman, the forgers, the countless others who make the parts.

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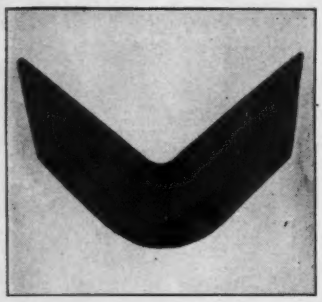

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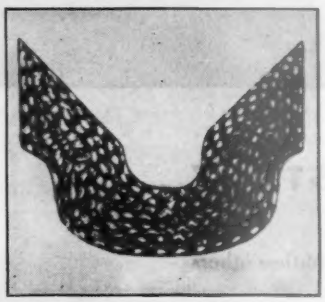

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"Survival in the Air Age"

(*Continued from page 35*)

port system or any important segment thereof. We believe that individual progressive carriers, desirous of developing air transport as a part of a coordinated service, should not be automatically prevented from such action simply on the grounds that they are surface carriers.

We recommend that the CAB be given economic control of all air carriers for hire.

We recommend that the present experimental period for feeder air lines remain at 3 years. If it becomes evident that this period can be extended without burdensome cost in mail pay, we recommend extensions. We also recommend that new certificates, if any, be granted for 5 years.

We agree with the present CAB policy which favors limited competition among American operators on international routes. We do not approve the chosen-instrument policy.

The CAB should be given control over international rates.

A State-local aviation panel advisory to the Air Coordinating Committee should be established in order to give official recognition to State and local aviation organizations at the Federal level.

We recommend Congress appropriate each year the full amount of Federal funds permissible under the Federal Airport Act of 1946.

Section V

GOVERNMENT ORGANIZATION

We recommend that the Government executive functions relating to civil aviation remain under the direction of the Secretary of Commerce who shall have immediately under him a Secretary of Civil Aviation in charge of a Department of Civil Aviation. The position of Administrator of Civil Aeronautics should be abolished and the functions, activities, and duties of the Civil Aeronautics Administration transferred to the newly formed department. We recommend that there be set up parallel to the Secretary of Civil Aviation a Secretary of Industry and Trade who would supervise a Department of Industry and Trade within the Department of Commerce.

There should be established an Aircraft Development Corporation authorized to pay all or part of the development cost of cargo or other nonmilitary planes, components, navigational aids, and safety appliances. The Corporation should also be authorized to make loans to manufacturers for development costs when it appears that such financing cannot be obtained from civilian sources.

There should be established an Air Safety Board within the Department of Civil Aviation to consist of three members appointed by the President subject to confirmation by the Senate. The Air Safety Board would be responsible for the investigation and analysis of air accidents and submit reports to the Secretary of Civil Aviation to be made public by him.

The promulgation of safety regulations should be transferred from the Civil Aeronautics Board to the Department of Civil Aviation.

The Civil Aeronautics Board should continue to be an independent agency, located within the Department of Civil Aviation for housekeeping purposes only. The membership of the Civil Aeronautics Board should be increased from five to seven in order that the practice of the Interstate Commerce Commission of operating by divisions may be adopted. The salary of Board members should be increased to $15,000 a year.

The Secretary of Commerce should be a member of the National Security Council.

The Secretary of Civil Aviation should be chairman of the Air Coordinating Committee.

Admiral Land on "A.T.A. Policy"

(*Continued from page 20*)

requires first of all an alertness to the possible development of problems before they become acute. Questions can be dealt with much more wisely and dispassionately if they are anticipated.

"Perhaps the best illustration of the policies pursued by the Air Transport Association in furthering the progress of the air transport industry is that of its "all-weather" unit, which we call the Air Navigation and Traffic Control group, A.N.T.C. for short.... A.N.T.C. went into operation in June, 1946, charged with the responsibility for estimating the operational problems of the future and suggesting or providing solutions for them before they became acute."

Development of Air Freight

"Then there was the development of air freight into a power in the national transportation scheme. In February of last year an organization within A.T.A. which we called Air Cargo, Inc., was transformed from a research group into a highly aggressive activity for the handling of air cargo.

"Air Cargo, Inc., is entirely a service organization for its members. Its broad purpose is to weave a network of handling facilities for air cargo across the nation, so that the speed of the airplane can be incorporated with surface transportation to improve and speed the national distribution of property and commodities.

"Another project the A.T.A. has undertaken is consolidation of airport terminal services.

"...A.T.A., however, has another function. The air lines are subject to pressures from without, which, if they were not resisted on a concerted industry-wide basis, would inhibit and hamper the air lines in their efforts to reach their ultimate goal.

"I hope by this time you have gained a definite impression of some of the air-line and A.T.A. problems. All of them do not concern you directly; on the other hand, we depend on you for solution of some of the most important.

"The aeronautical sciences are wedded firmly to scheduled air transport and the union will grow stronger in the future."

What Air Lines Need

"What do we need from you?

"We need the instruments, both air-borne and ground-based, which will raise the safety factor above the hazards of weather and provide dependability. We need improved communications, more and better weather information, and better planes. We need a plane type that will permit the air lines to carry cargo at lower cost and greater efficiency. We need a plane to fit the special requirements of local service air lines. Those are physical things. But what we need most is a continuance of the fine spirit that has existed between technical, manufacturing, and air transport organizations, so that the American flag companies may always remain the best in the world."

General Powers on "Design for Mass Production"

(*Continued from page 21*)

eliminated. Otherwise the cost in time of building and maintaining tooling will be exorbitant, the advantages of interchangeability will be lost, and maintenance will be costly and difficult.

"As wing panels and fuselages have been made smaller and more streamlined to achieve greater speed, the amount of equipment which must be packed into the structure has increased.

"The gravity of the situation is emphasized by the fact that allowance must be made for production, maintenance, and servicing difficulties in computing requirements. Coupled with the necessity for filling the pipeline, this subjects the industry to a burden which might well be fatal.

"An airplane on the ground undergoing maintenance or servicing is not only useless but highly vulnerable. The utilization factor thus becomes a matter of critical importance in determining numerical requirements."

Never Sure When Enough Is Enough

"We do not know how much time we will have. We will never be sure when enough is enough, nor can we ever be sure that we have the capacity to produce enough. Consequently, we must do everything within our power to eliminate production delays and increase the utilization factor, while at the same time preserving functional superiority.

"Only in this way, and not through blind faith in our ability to produce in unlimited quantities, can the Air Force and the aircraft industry together find assurance that we may be able to meet any future emergency."

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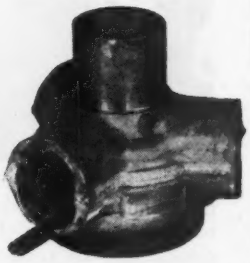
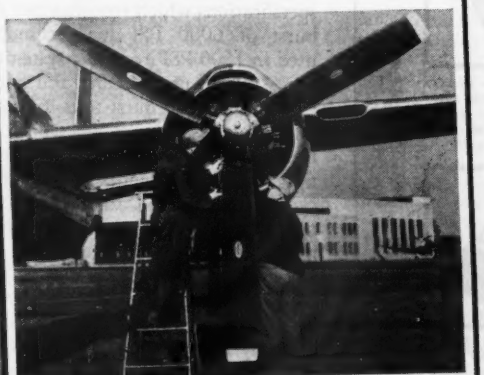
PRESSURE WELDED BY
WYMAN-GORDON PROCESS
NICKEL-CHROMIUM-MOLYBDENUM
STEEL

Two halves of forged nickel-chromium-molybdenum steel propeller barrel, machined and ready for assembly by pressure welding into a one-piece hub.



A heat treated assembly ready for shipment. Immediately after welding, hubs are stress-relieved to prevent cooling cracks, and to allow removing weld upsets before heat treating.



Designed to absorb more horsepower and deliver more thrust for a given diameter than any 3-blade propeller now in production, the new Hamilton Standard reversing Hydromatic type provides for either reverse thrust, or feathering in less than 3 seconds.

NEW TYPE HUB
HELPS
HAMILTON STANDARD PROPELLERS

- **Absorb More Power**
- **Deliver More Thrust**
- **Reverse in 3 Seconds**

Here's a hub structure that helps a new type three-blade propeller assembly attain the most favorable weight-to-size ratio ever developed.

The hub . . . first of its kind to be produced in one piece . . . is assembled by pressure welding two forged barrel halves of nickel-chromium-molybdenum steel, Type 4350.

This grade of nickel alloyed steel, long a standard material for hubs and other vital aircraft forgings, permits making strong, sound welds of good mechanical properties.

A special welding process for producing the new hub was developed by Wyman-Gordon Company, Worcester, Mass., which fabricates these parts for Hamilton Standard Propellers Division of United Aircraft Corporation, East Hartford, Conn.

Tests of some twenty production-welded barrels after heat treatment, showed properties averaging as follows:

Yield Strength (0.2% set), p.s.i.	**122,160**
Ultimate Tensile Strength, p.s.i.	**143,300**
Elongation in 2", %	**15.0**
Reduction of Area, %	**36.2**

Metal problems differ, but the wide range of nickel alloy steels allows selection of exactly the correct one for each specific application. Consult us on the use of nickel alloys in your products or equipment.

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Over the years, International Nickel has accumulated a fund of useful information on the fabrication, treatment, properties and performance of engineering alloy steels, stainless steels, cast irons, brasses and bronzes, and other alloys containing Nickel. This information is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

HYDRAULIC DEVELOPMENTS

Atomic Hydrogen Welding

The shells for most spherical hydraulic pressure accumulators have been made by joining two hemispheres with a ring or series of bolts at their equator. This method of fabrication, however, tended to increase the bending stresses in the shell and added to the danger of fragmentation under gunfire. In the design of pressure vessels for military aircraft, these factors are of primary importance.

In an effort to develop an accumulator shell which would be more satisfactory from standpoints of both stress and fragmentation, the Pacific Division of Bendix Aviation Corporation eliminated the joint at the equator through permanently joining the two hemispheres by means of Atomic Hydrogen Welding, which also, incidentally, has the effect of greatly reducing the weight of the accumulator.

The principles of this method of welding are as follows: an arc is struck between two tungsten electrodes which are held close to the work. Gaseous hydrogen flows through the path of the arc from openings in the electrodes. The temperature of the arc breaks molecular hydrogen down into atomic form, and nascent hydrogen, escaping from the arc and approaching the relatively cool metal of the shell, recombines and releases the heat absorbed in the arc, accomplishing the weld. The temperature gradient across the weld zone is less severe than with other methods, and the hydrogen acts as a powerful reducing agent which, by excluding oxygen, helps to preserve the original properties of the metal.

Many tests were made to determine the optimum wall thickness in order to build an accumulator of maximum efficiency; i.e., an adequate margin of safety without excess weight. Hydrostatic burst tests were conducted to insure that the Bendix Accumulators would conform to Army and Navy specifications which require a minimum burst of 6000 PSI for accumulators used in 1500 PSI hydraulic systems and 12,000 PSI if used in 3000 PSI systems.

In addition to burst tests, prolonged fatigue tests were conducted. It was found virtually impossible to cause fatigue failure of Bendix shells even by cycling them from 0 to 3000 PSI without air pre-load in the bladder. Even more gruelling tests were then conducted by cycling at 0 to 5000 PSI, still without air pre-load in the bladder. The results of these fatigue tests proved conclusively that the Bendix Accumulator Shell will last indefinitely on an airplane.

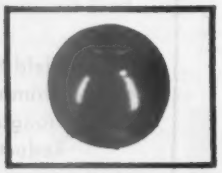
Bendix-Pacific Engineers are continuously working to improve the accumulator; tests now in progress are proving the use of the accumulator at lower temperatures and with new non-inflammable hydraulic fluids.

One Piece Shell — *Achieves lightest possible weight and longest fatigue life, due to inherent stress efficiency of spherical shell with no flanges.*

THE outstanding characteristics of all Bendix-Pacific Accumulators — for both 1500 and 3000 PSI systems — have been time-tested on nearly 100,000 military and commercial aircraft under every conceivable operating condition. Let us send you the complete story on these and other Bendix-Pacific hydraulic products.

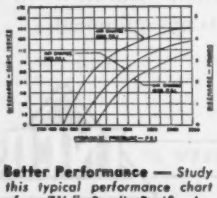
Easy Service — *Inspection is accomplished by simply removing the air cap. The bladder is easily removed or replaced.*

12,000 PSI Burst Strength *in the 3000 PSI accumulator and 6000 PSI in the 1500 PSI unit prove that structural soundness is not sacrificed for light weight.*



Long Life Bladder — *Because of unconventional design, flexing is distributed over an extended area, avoiding local failure which shortens life.*

Won't Shatter — *Freedom from fragmentation has been conclusively demonstrated on gunfire tests and in actual use.*



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Professors or Instructors—Salaries comparable to industrial salaries. Opportunities for research and writing. Excellent facilities. Fields: engineering, transportation, and operations. Address: Director, University of Southern California, College of Aeronautics, Santa Maria, Calif.

Helicopter Aerodynamicist—Experienced, required for long-term development program for U.S. Air Force. Apply in writing to Manager, Helicopter Division, Kellett Aircraft Corporation, North Wales, Pa.

Aerodynamicists, Thermodynamicists, Stress Analysts, Aircraft Designers—North American's engineering program offers a number of excellent openings in the classifications above for qualified engineers. Salaries commensurate with training and experience. Please include complete details in reply. Engineering Personnel Office, North American Aviation, Inc., Municipal Airport, Los Angeles 45, Calif.

Aerodynamicists—With experience in stability and control work and flight testing. Positions require a good academic background and sound knowledge of dynamics and applied mathematics. Advanced degree desirable. Must have training, experience, and ability to assume major responsibility in both the theoretical and experimental flight-test phases of major programs of aircraft flight dynamics and be familiar with standard methods of flight data reduction. Write Employment Office, Cornell Aeronautical Laboratory, 4455 Genesee St., Buffalo 21, N.Y.

Research Engineers—Openings for experienced aerodynamicists, thermodynamicists, and electronic engineers with opportunity for research in supersonics. Openings also for engineers with jet-engine test experience. Please include complete résumé of experience and education in reply. Write to: Consolidated Vultee Aircraft Corporation, Lone Star Laboratory, Daingerfield, Tex.

Aeronautical Engineers—Aircraft research engineers and scientists needed for work on task research programs. Projects under way require men with the ability to apply the theories of dynamics, structures, aerodynamics, thermodynamics, and aircraft design to the solution of varied applied research problems on airplanes, helicopters, and guided missiles. Educational background and knowledge should approximate that required for a Masters Degree in Engineering or Physics. Experience desirable but not so essential as a good basic training and a well-developed scientific curiosity. Cornell Aeronautical Laboratory, Employment Office, 4455 Genesee St., Buffalo 21, N.Y.

Flutter Engineer—Aeronautical Engineering graduate with several years of experience in flutter and vibration problems for work on advanced military aircraft. Address reply to Engineering Personnel Office, North American Aviation, Inc., Municipal Airport, Los Angeles, Calif.

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Assistant Professor or Instructor—Staff member to teach aircraft structural analysis and applied mechanics; also to set up complete structural testing laboratory. Must be familiar with aircraft structural practices in order to work with local aircraft industry. Previous teaching experience desired but not essential. Please give brief sketch of education, experience, and personal qualifications. Address, Kenneth Razak, Head of Aeronautical Engineering Department, University of Wichita, Wichita, Kan.

834. Helicopter Pilot—Experienced helicopter pilot with over 150 hours' helicopter time. Commercial operator desires chief pilot to take charge of operations.

832. Mechanical Designer—Instrument field, Long Island area. Must be capable of handling complete design of small, precision mechanical computers involving numerous automatic inputs.

830. Engineer—High caliber; flight-test operations experience necessary; pilot experience desirable. Must be graduate engineer. East Coast.

823. Pilots—Experienced helicopter test pilots wanted. Must have a minimum of 100 hours of helicopter flying time. Engineering background desirable. Preferably service trained. East Coast concern.

812. Engineer—Production—Trained in designing for low-cost production. Must be a graduate engineer and have aircraft experience. Progressive and expanding concern in metropolitan Philadelphia area. Send complete résumé.

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804. Theoretical Aerodynamicist—A Ph.D. in Aeronautical Engineering, Mathematics, or Physics is needed at a large Midwestern university as an associate professor or professor in the Department of Aeronautical Engineering to teach advanced theoretical courses in aerodynamics. The duties would include advanced undergraduate and graduate teaching through the Ph.D. level and the direction of theses. Opportunities for research, research consultation, and industrial consultation exist.

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845. Controls Engineer—B.S. in Ae.E., graduate study. Six years' design and supervisory experience with major air-frame and accessory manufacturers. Electronic experience in military service. Specialization—electrical and hydraulic equipment for operating power-plant controls, armament, landing gear, surface controls, and accessories. Some experience with automatic pilots, data transmission systems and other forms of automatic controls. At present installations engineer with accessory manufacturer. Location Midwest or West of Mississippi.

844. Director of Research—Holds B.E., M.S., Ph.D. degrees in Metallurgy and M.S. in Aeronautics (jet propulsion major). Eight years in industry and 2½ years in Navy on guided missile programs. Seeks executive position where organizational and administrative talents may be used.

843. Air-Line Engineering Executive—Graduate engineer, age 41. Nineteen years' all-round experience in air-line engineering and maintenance including 6 years' experience as factory representative developing new aircraft. Desires new contact with expanding possibilities.

842. Associate Professor—Associate Professor of Aeronautical Engineering, Doctor of Aeronautical Engineering, seeks change of position. Possesses engineering, as well as mathematics, advanced degrees. Major field: theoretical aero dynamics and gas dynamics.

841. Aeronautical Engineer—Structures engineer desires change. B.Ae., N.Y.U., 1942. Four years' experience in aircraft structural design, including research in thick skin and sandwich construction. Prefers position in business associated with aircraft field work or sales. Open to any interesting offer affording possibilities for a good future.

840. Aeronautical Engineer—M. Aero. Eng.; age 33. Ten years' experience in flight-test and operational engineering, air-line operations, sales and market research, and technical writing. Wide contacts in air-transport and manufacturing fields. Desires position as assistant to executive, sales engineer, in New York or New England area.

839. Helicopter Engineer—Chief designer and project engineer on two helicopters. Author of book on helicopter design. Five and one-half years of helicopter experience. Available immediately.

838. Aeronautical Engineer—B.S. in M.E., B.S. and M.S. in Ae.E.; age 46; married. Professional engineer with seal. Ten years of structural design and analysis as per Army, Navy, and C.A.A. specifications. Two years of engineering methods standardization. All with major aircraft companies. Desires responsible position in aircraft or related field.

837. Aeronautical Structural Engineer—Graduate engineer with 20 years' experience in all phases of aircraft structural design on fixed and rotary wing aircraft. For past 10 years has held position of chief structural engineer with well-known manufacturer of military airplanes. Had complete responsibility for structural analysis, vibration and flutter, structural testing, and weight control. Desires connection with established organization in which his background and experience can be used to advantage.

836. Aeronautical Engineer—B. of Ae., New York University, 1944. During last year engaged in research in supersonics in a large research or-

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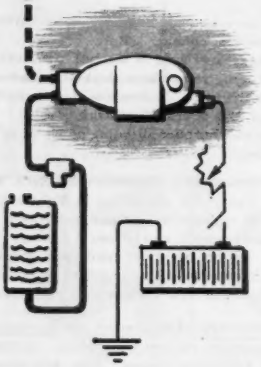

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835. Development Engineer—Wide plastics structures background. Has had positions of design engineer, test engineer, chief test engineer, and assistant chief engineer with medium-sized Eastern aircraft firms. Used to responsibility and difficult problems. Desires position with company doing research and development work, especially in the design and construction of large reinforced plastic structures for aircraft or allied fields.

833. Research and Development Engineer—Physicist and aeronautical engineer; age 37. M.S. in Aeronautical Engineering, California Institute of Technology; D.Sc. in Physics; Fellow, Institute of Physics, London. Willing to accept suitable position in research institution, in university, or in the research and development division of large industrial concern engaged in aeronautical or allied activity. Twelve years' overall experience in physical research and aeronautical engineering. Author of a number of papers and reports on several branches of physics and aeronautics. Considerable aptitude for invention. U.S. patent for aeroplane C. G. Calculator pending. Formerly held responsible position in U.S. aircraft concern. Excellent references in U.S. and India.

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828. Aeronautical Engineer—B.S. Ae.E.; age 29; married. Five years' experience, including performance estimation, stability and control analysis, aeronautical research and wind-tunnel testing, and stress analysis on military and commercial aircraft. Familiar with C.A.A. requirements. Desires permanent position in above or related fields, preferably on West Coast.

827. Mechanical or Aeronautical Engineer—M.S. Desires position that combines engineering or research with administrative duties, East Coast, preferably New England. Last 4 years as aerodynamicist, designer, and development engineer on guided missiles projects; previous experience includes 8 years of extensive research, consulting work, and teaching at leading Eastern engineering school. Details and references upon request.

826. Aeronautical Engineer—M.S. in Ae.E. Over 4 years' experience with major aircraft companies, mainly in flutter and vibration work.

825. Quality Control Executive—Experienced in organizing and administering mechanical inspection and maintenance of aircraft and motor vehicles, recruiting and job evaluation for over 500 civilian office and technical personnel. Qualified airplane pilot—5,873 military hours, all types. West Point graduate, 1923. Aeronautical engineer.

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816. Aeronautical Engineer—B.Ae.E., Rensselaer Polytechnic Institute; age 29; married. Four and one-half years' experience in the Engineering Division, Air Materiel Command, Wright Field, engaged in flutter research, ground vibration testing and evaluation, wind-tunnel testing, and development of vibration measuring equipment. Two years' experience in the U.S. Navy at Bureau of Aeronautics, Washington, D.C., in the Aviation Design Research Branch, engaged in the study of flight paths and other special problems related to guided missiles. Desires position in research or development.

795. Aeronautical Engineer-Pilot—B.S. in Ae.E. from University of Michigan. Age 32; married. Two years in present position designing major units for leading aircraft manufacturer. Familiar with Army, Navy, and C.A.A. requirements. Naval aviator for 7 years. Twenty-four hundred hours flight time. Two years' experience supervising 25 mechanics and the maintenance of 20 dive bombers aboard an aircraft carrier. Seven months as executive officer. At present commanding officer of an air group and fighter squadron in the Organized Naval Reserve, with former rank of Lieutenant Commander. Holds C.A.A. commercial single- and multiengined land and instrument ratings. Desires position combining flying and engineering or flying and administrative-executive work.

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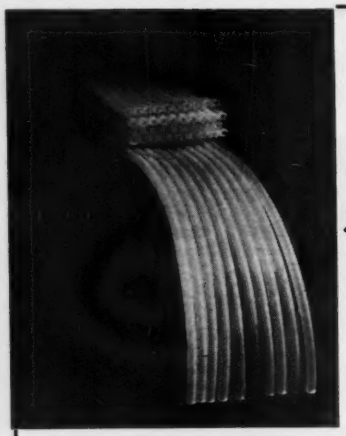

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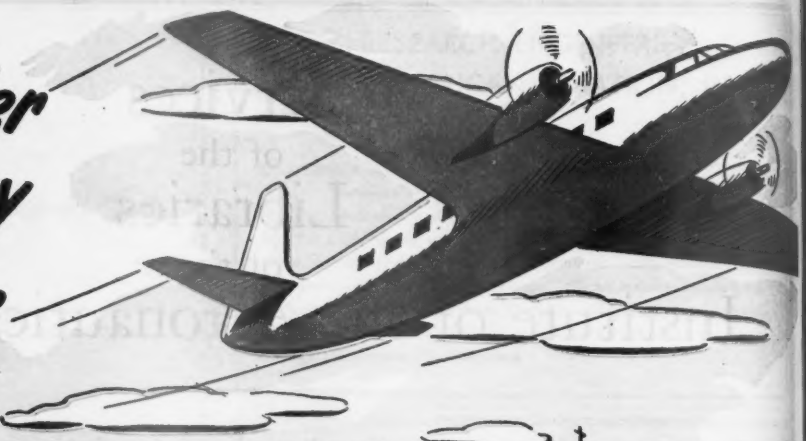

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If you are faced with problems in the transmission of power, call on Foote Bros. Our engineers will assist in the development of gears and gear units to meet any need.

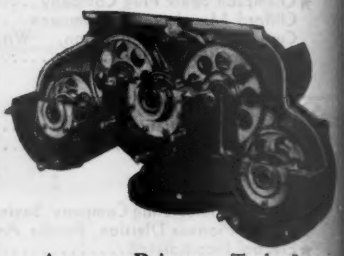
Precision Gears: Foote Bros, "A-Q" (aircraft quality) Gears permit high loading coupled with light weight. They bring new standards of speed, compactness, low noise level, and, above all, assure an efficiency that marks a new advance in gear design.

Commercial Gears: Complete facilities backed by nearly a century of experience are available for the production of high quality spur, worm, helical, bevel and internal gears—any size—any quantity.

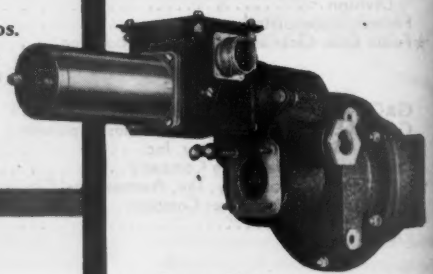
Power Units and Actuators: These units are individually engineered to solve many problems of power application and control. They may be designed to fit a confined space envelope, will operate on an exact time cycle and offer the advantages of high speed operation where desired.

Speed Reducers: For years, manufacturers have relied on Foote Bros. for speed reducers for all types of commercial applications. The complete line includes helical gear and worm gear reducers in a wide range of sizes and ratios.

The Hi-Hat vertical shaft speed reducer provides greater span between bearings and rigidity for the extended shaft. Upper bearing is positively lubricated.



Accessory Drive on a Turbo Jet engine. Power is transferred from the engine shaft through a spiral bevel and spur gear reduction system.



Power Unit on the Northrop YB-49 Flying Wing Bomber. This unit is part of the Elevon Control System required to maneuver the airplane.

This large gear, twenty feet in diameter, was produced by Foote Bros. to drive a ball mill. It typifies the facilities of this company to manufacture gears of exceptional size.

An unusual pair of "A-Q" Gears manufactured for the largest propeller in service—the Curtiss C636S. A limited space envelope and the demands for light weight require gears of extremely thin sections. Despite this, they must carry heavy loads.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION
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WRITE FOR BULLETINS

Three engineering bulletins are available to assist your engineers. They are: (1) *"Whatever Your Needs in Quality Gears";* (2) *"Aircraft Quality Gears" and* (3) *"Foote Bros. Power Units." If you have not received copies, write for them.*